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Field Experiments with Tobacco, Season 1939-40.

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Since 1934 tobacco experimental and extension work in all the Australian States has been aided considerably by a grant from the Commonwealth Government.

From January, 1934, to December, 1938, West Australia's share of this grant amounted to £6,250 and during this period the State's reputation as a producer of high quality tobacco leaf steadily advanced. In recognition of this fact, the Commonwealth Tobacco Grant to Western Australia for the ensuing five-year period, January, 1939, to December, 1943, was increased to £9,000.

In fixing the basis of allocation "regard was had to the potentialities of the respective States as producers of good quality leaf, the needs of the industry with respect to research and investigation in the various States and of the welfare of the Australian tobacco industry as a whole, bearing in mind the experience which had been gained during the past five years."

It is worthy of record, therefore, that Western Australia was the only State in the Commonwealth to receive an increased grant at this time, and as a result, a considerable increase in the scope of the experimental work at Manjimup was made possible.

Two areas, each of six acres, were leased, one on the property of Mr. G. F. Combs at Jardee, and the other on Mr. W. E. Henwood's property at the Donnelly River. Both areas, which had been previously under cultivation, were totally cleared of standing dead timber and stumps, fenced with rabbit-proof netting and equipped with the necessary curing barns, bulking and grading rooms and stringing and conditioning sheds.

The areas selected were typical of much of the land on which tobacco is grown commercially at Manjimup, being on moist flats situated between heavily timbered ridges carrying karri and redgum (marri). As land of this type is liable to become badly waterlogged during the wet winter months a number of tile drains were laid at both stations in order that green manure and fodder crops could be grown through the winter. The drainage systems were designed with the help of Mr. A. R. C. Clifton, Irrigation Officer, and they have proved very effective.

Each station has been divided into three sections of two acres each, to permit of a three-year rotation. At our request and prior to cropping, a detailed soil survey is being carried out at both stations by colleagues in the Soils Branch, borings being taken at quarter-chain intervals. Work done so far, both at the stations and at various other locations in the Manjimup district where tobacco has been grown commercially, has revealed very great variability of these valley soils over short distances, especially in the subsoil characteristics. There is ample evidence that this soil variability affects the growth and quality of tobacco to a marked extent, and this factor is likely to complicate the task of analysing the results of the various experiments.

The work of draining and clearing the stations was carried out under conditions of considerable difficulty owing to the very wet winter experienced, but the work was sufficiently far advanced by the Spring to permit of planting the 1939 crop, although the ground, particularly at Jardee, did not receive the thorough preliminary cultivation which is considered desirable. Planting of the various experiments was commenced during the second week of October and all experiments were repeated at both Research Stations. An ample supply of well grown, healthy seedlings was available from the Department's experimental and demonstration seed-beds situated at Manjimup and for the most part planting was carried out under quite favourable weather conditions. A very heavy infestation of slugs on some of the moister patches of soil caused some damage and necessitated some replanting, but they were quickly controlled by the use of "Meta" and bran bait.

The growing season was a very dry one. The following table gives the monthly rainfall recorded at Manjimup:—

October	..	..	..	399	points.
November	..	..	..	159	"
December	..	..	..	17	"
January	..	..	..	47	"
February	..	..	..	14	"

It will be seen that very little useful rain fell after the end of October. In spite of this the major part of the crop at both stations made excellent growth, many of the plots giving very high returns, both in weight and value of leaf.

Harvesting commenced about the middle of January and finished about the middle of March, eight pickings of leaf being obtained from each of the Stations. Grading was done during June, July and August. The leaf from each plot was graded separately, and the weight and estimated value per lb. of each grade recorded. These estimated values were later amended in accordance with the prices actually received for the leaf at the auction sale conducted by Dalgety & Co. at Fremantle on 2nd September, most of the grades fetching threepence per lb. more than the estimated value. This was doubtless due to war conditions increasing the demand for Australian leaf generally. Details of the various experiments are given below.

MINOR ELEMENT EXPERIMENT.

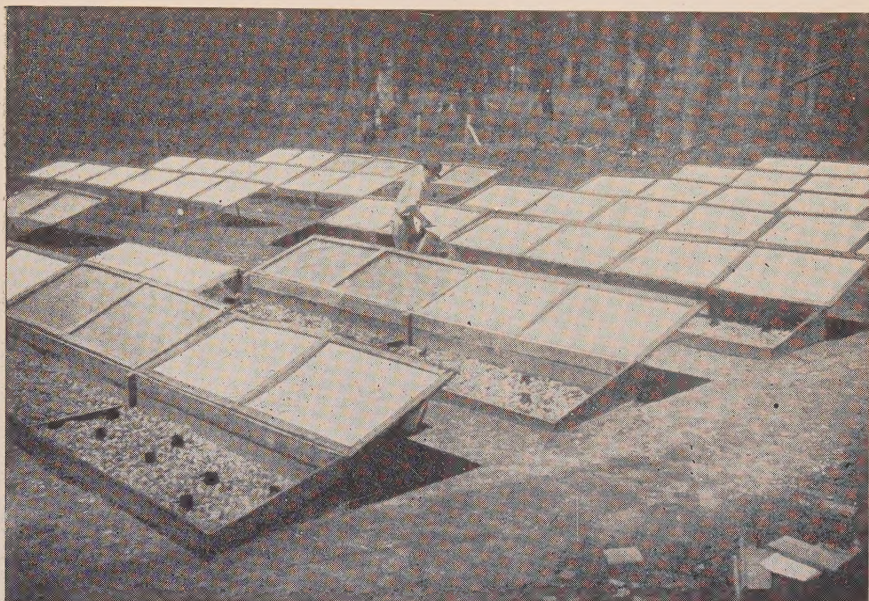
Object.—To study the effect on yield and leaf quality of various minor elements when added either singly or in combination to the standard tobacco fertiliser used in this State, and to determine whether the addition of one or more of these elements will enable a reduction to be made in the amount of fertiliser required to produce a normal crop.

The minor elements tested were zinc, copper, manganese and magnesium applied as sulphates at the rate of 15 lbs. per acre, and Boron applied as sodium borate at the rate of 5 lbs. per acre.

These elements were added either singly or in combination to standard tobacco fertiliser at two levels, namely 1,000 lbs. per acre representing a usual commercial application, and 500 lbs. per acre.

The experiment consisted of 64 plots laid out in four blocks, each of sixteen treatments.

Each plot consisted of one row, one chain long. The rows were four feet apart and the plants were set at intervals of two feet in the rows. The fertiliser was applied in the rows at four to five inches depth and the variety planted was Kelly. The experiment was planted on 20th October at Donnelly Station and on 27th October at Jardee.



General view of departmental tobacco seed-beds.

(Photo by A. Sharp.)

A number of the plots in this experiment at Donnelly developed rather serious "frenching" but close examination of the area affected failed to show that any of the elements tested had any effect in reducing the severity of this condition, the cause of which is still unknown. On both stations, some plots seemed to show rather better growth than others and some of the plots which received only half the standard amount of fertiliser made growth quite comparable with those which received the standard amount. On the whole, however, indications were that variations in soil type had more effect on growth than any particular treatment.

Statistical analysis of the results showed that none of the minor elements influenced total yields or values at either Station.

It is of interest, however, to note that no significant difference in either total yields or values could be detected between the 1,000 lbs. per acre fertiliser level or the 500 lbs. per acre level.

As these results are obtained from one year's experiments only they must be interpreted with caution at this stage.

VARIETY EXPERIMENT.

This experiment was laid out in the form of a latin square and eight varieties were tested, namely, Hickory Pryor, Kelly, Cash, Gold Dollar, Bonanza, No. 35 White Stem Orinoco, Yellow Mammoth and White Mammoth. Standard tobacco fertiliser at the rate of 1,000 lbs. per acre was applied in the rows and the plants were set out on 26th October at Donnelly and 27th October at Jardee.

Part of this experiment also was badly affected with frencing at the Donnelly Station and all varieties appeared to be equally susceptible to this condition. The incidence of frencing caused considerable variation in block yields and also in the inter-relationship of varieties within the blocks.

RESULTS OF VARIETY TRIALS.

DONNELLY AND JARDEE TOBACCO RESEARCH STATIONS.

Table of Means of Total Weight of Cured Leaf (lb. per acre).

Station.	Yellow Mammoth.	White Mammoth.	Hickory Pryor.	Kelly.	Cash.	No. 35 White Stem Orinoco.	Gold Dollar.	Bonanza.
Jardee	408	498	442	344	438	427	451	466
Donnelly	1213	1264	1208	1319	1087	1086	1043	1091

Donnelly—P.05 difference for significance = ± 185 lbs.

Jardee—No difference between varieties.

Table of Means for Value of Cured Leaf (£ per acre).

Station.	Yellow Mammoth.	White Mammoth.	Hickory Pryor.	Kelly.	Cash.	No. 35 White Stem Orinoco.	Gold Dollar.	Bonanza.
Jardee	31.5	38.6	24.1	17.5	25.2	30.5	31.4	42.5
Donnelly	116.1	120.1	79.9	75.3	88.0	101.7	94.8	114.7

Jardee—P.05 difference for significance = $\pm £11.3$.

Donnelly—P.05 difference for significance = $\pm £21.9$.

Taking into account the fact that only differences between the mean acre yields of varieties which are greater than 185 lbs., are statistically significant, an analysis of the yield results at Donnelly shows that the yields per acre of all varieties except Kelly and White Mammoth did not differ.

Kelly gave a significantly higher yield than Cash, White Stem Orinoco, Gold Dollar, and Bonanza, whereas White Mammoth gave a significantly higher yield than Gold Dollar only. Despite its high yield per acre at Donnelly, the variety Kelly had a significantly lower value per acre at this Station than White Mammoth, Yellow Mammoth, Bonanza, and White Stem Orinoco, and a similar value to the remaining varieties. White Mammoth on the other hand, produced leaf of excellent quality which had a higher value per acre than that of Hickory Pryor, Kelly, Cash and Gold Dollar, and a similar value per acre to Yellow Mammoth, Bonanza, and White Stem Orinoco.

Yellow Mammoth and Bonanza gave a greater value per acre than Hickory Pryor, Kelly and Cash, but White Stem Orinoco gave a greater value per acre than Kelly only.

At Jardee the yield and value of all varieties was unsatisfactory, growth throughout the season being poor. This was no doubt due in part to insufficient cultivation of the area before planting owing to difficulties encountered in clearing and draining.

The results at both stations emphasise how misleading total yield may be as a criterion of varietal suitability, unless leaf value or quality is also taken into account. Thus at Donnelly, the variety Kelly gave the high yield of 1,319 lbs. per acre, valued at £75.3, whereas the variety Bonanza, for example, gave a lower acre yield of 1,091 lbs. which was valued at the high figure of £114.7. Observation of commercial crops of Kelly confirmed this result. Generally speaking, in spite of the very dry weather conditions experienced, these made quite good growth but the leaf when cured had a harsh, boardy texture which seriously detracted from its value. The varieties White and Yellow Mammoth, Bonanza, and White Stem Orinoco, which are comparatively recent introductions, compared very favourably with the older standard varieties Hickory Pryor and Cash.

TIME OF PLANTING AND SUBSEQUENT CULTIVATION EXPERIMENT.

Object.—To determine the relative merits of early, midseason and late planting, together with the effect on yield and quality of leaf of three different types of cultivation during the growing period, viz., (a) shallow flat cultivation, (b) deep flat cultivation, (c) hilling the rows.

PLAN OF TIME OF PLANTING AND SUBSEQUENT CULTIVATION EXPERIMENT.

—	Block 1.	Block 2.	Block 3.	Block 4.
C. Hilling				C.
A. Shallow Flat Cultivation ...	1st Planting	2nd Planting	3rd Planting	2nd Planting A.
B. Deep Flat Cultivation ...				B.
B. Deep Flat Cultivation ...				B.
C. Hilling	3rd Planting	3rd Planting	1st Planting	1st Planting C.
A. Shallow Flat Cultivation ...				A.
B. Deep Flat Cultivation ...				B.
A. Shallow Flat Cultivation ...	2nd Planting	1st Planting	2nd Planting	3rd Planting A.
C. Hilling				C.

The experiment was laid out on a split plot design (see plan), there being four replications of three cultivation treatments combined with three planting dates. The treatments were randomised. Each plot consisted of three rows one chain long. The rows were four feet apart and the plants were set at intervals of two feet in the rows. Only the middle row of each plot was used in computing the yield. Tobacco fertiliser at the rate of 1,000 lbs. per acre was applied in the row at a

depth of about four inches on the day before the plants were set out. The dates of the three plantings at Jardee were 12th and 27th October and 10th November, and at Donnelly 18th October and 1st and 15th November.

Hand and horse hoeing on each plot was commenced about ten days after planting, and the hilling of section (c) was done on 5th and 6th December except for the last planting at Donnelly which was done on 22nd December. The hilling was done with a small garden plow as no suitable horse implement was available. The final cleaning out of the centre of each row was done with a scuffler fitted with a long hilling attachment. Sections (a) and (b) were cultivated frequently with a horse scuffler fitted with diamond points, the former to a depth of about two inches and the latter as deep as the points would go.



Pulling plants from seed-beds.

(Photo by A. Sharp.)

The outstanding feature of the experiment as the plants reached maturity was the appearance of the hilled plots. Even from a distance the rows which had been hilled stood out from the rest of the crop owing to the very dark green colour of the foliage, an effect very similar to what might have been expected from a heavy dressing of nitrogenous fertiliser. Generally speaking, individual plants in the hilled rows had thicker, stronger stalks, larger leaves of a darker green, and an appearance of greater vigour and yield than those in the rows cultivated on the flat. In some of the replications the plots receiving shallow cultivation appeared to make slightly better growth than those deeply cultivated, but the difference was not very outstanding. The effect of hilling was definitely to retard ripening of the leaf which was still quite immature on the hilled plots when harvesting of the other plots commenced in mid-January. During February, however, the leaf on the first two plantings of the hilled plots ripened rapidly and the top leaf was ready for picking at practically the same time as that on the corresponding plots grown on the flat. The hilled plots of the third planting were late in ripening all through and the plants carried anything from five to ten unripe leaves on 12th March, by which time harvesting of the rest of the experiment had been completed.

With regard to time of planting, as would be expected, the plots ripened in the order of planting, but as harvesting advanced the later planted ones tended to catch up to the others until there was a difference of not more than one week between the first and last plantings.

Statistical analysis of yields and values per acre obtained at Jardee showed no effect of treatment except that there was a trend in favour of hilling so far as total weight of leaf was concerned. The increase in total yield was not accompanied by any corresponding increase in value, however, due to the heavier, coarser type of leaf produced not being in demand by buyers except at comparatively low prices.

At Donnelly the mean yields per acre from the different cultural treatments were as follows:—

Shallow flat cultivation	= 1,460 lbs. per acre.
Deep flat cultivation	= 1,319 lbs. per acre.
Hilling	= 1,646 lbs. per acre.



Planting the plots.

(Photo by A. Sharp.)

As the difference for significance between the mean yields of the three treatments was 203 lbs., it will be seen that hilling was better than deep flat cultivation, but did not differ from shallow flat cultivation. At both stations, therefore, results indicate that hilling shows promise of becoming a valuable method of increasing the total yield, a fact borne out by observations during the growing season.

At Donnelly late planting gave the best results from the point of view of value, while the late planting with hilling gave the very high total yield of 2,077 lbs. of cured leaf per acre (average of four plots). It may be pointed out that the values obtained for the heavier leaf from the hilled plots are probably somewhat lower than might be expected from a commercial crop grown by this method, as it had to be cured at the same time as leaf of finer texture from the other plots. The two types require rather different treatment during curing, and in practice the

small amount of thick leaf had to be cured out too quickly in order that the best results might be got from the much larger amount of finer leaf harvested from the rest of the experimental areas.

SPACING EXPERIMENT.

Object.—To determine the effect on yield and quality of leaf of various spacings of plants in the rows.

The spacings used were 18 inches, 30 inches and 42 inches. As the effect of spacing might vary as between different varieties the experiment was duplicated, one-half being planted with Bonanza and the other with Kelly at Jardee, while at Donnelly the varieties Cash and Kelly were used.

The effect of the spacings became obvious as the plants approached maturity. The leaf on the plots with 18-inch spacing was smaller and thinner than that on the wider spacings, that on the 42-inch spacing tending to be large and distinctly coarse, particularly at Jardee. Ripening commenced earlier with the closer spacing, the bottom leaf turning a nice pale pea-green by the middle of January. Ripening of the heavier leaf on the wide spacing plots was nearly a fortnight later and was evidenced by mottling rather than by a general lightening of colour.

SPACING EXPERIMENT.

General Table of Means on an Acreage Basis.

Station.	18in.		30in.		42in.	
	Total Yield.	Total Value.	Total Yield.	Total Value.	Total Yield.	Total Value.
	lb.	£	lb.	£	lb.	£
Donnelly (Cash) ...	1102	77·2	918	76·6	734	62·7
Do. (Kelly) ...	1191	75·5	1118	72·2	848	65·8
Jardee (Kelly) ...	1454	75·0	1314	71·9	1066	56·7
Do. (Bonanza) ...	1637	147·6	1367	131·8	1022	95·4

Statistical analysis of the yields and values showed that at the Donnelly Station, with the Cash variety, the 18-inch spacing gave the heaviest yield with 30-inch next and 42-inch worst. (P.05 difference for significance 147 lbs.) With Kelly there was no significant difference between 18-inch and 30-inch but both were better than 41-inch. (P.05 difference for significance 180 lbs.). So far as value was concerned there was no significant difference between the various spacings with either variety.

At Jardee, with Kelly, 18-inch spacing was better than 42-inch, but neither differed significantly from 30-inch in total yield. (P.05 difference for significance 267 lbs.) With Bonanza, 18-inch was best, 30-inch next and 42-inch worst in total yield. (P.05 difference for significance 280 lbs.) With Kelly there was no significant difference in value between spacings, while the Bonanza 18-inch and 30-inch values were greater than 42-inch. (P.05 difference for significance £23.5.)

Here again, it is thought that the accuracy of the figures obtained for value was lessened somewhat as the three distinct types of leaf obtained really required different curing treatments. As this was impossible the cure had to be a compromise between the three. Judging by its appearance in the field, however, there is no doubt that the finer leaf obtained from the closer spacing was the type most in demand by the manufacturers.

At a later stage it is hoped that an experiment may be conducted in which closer spacing is combined with the hilling method of cultivation, for possibly under these conditions, ripening of the hilled plots may be hastened while leaf quality may be improved considerably.

As already mentioned the soil variation at both stations was very great and further experience may indicate the advisability of adopting larger units in order to increase the reliability of plot yields.



View of the crop at the Donnelly Research Station.

(Photo by A. A. Johnston, Manjimup.)

In addition to these experiments, a test was conducted with a fertiliser mixture which, while containing the same amounts of nitrogen, phosphoric acid and potash as the standard tobacco fertiliser, included a proportion of nitrogen in organic form and a small proportion of chlorine, with a reduced amount of sulphur. This mixture also contains smaller amounts of those ingredients which have to be imported and which may therefore be difficult to obtain under wartime conditions.

The fertiliser mixtures were as follows:—

<i>Standard.</i>				<i>Special Mixture.</i>			
			lbs.				lbs.
Nitrate of Soda ...	...	...	59	Nitrate of Soda ...	...	...	43
Sulphate of Ammonia ...	...	...	117	Sulphate of Ammonia ...	...	...	32
Superphosphate ...	...	...	706	Blood and Bone ...	...	...	111
Sulphate of Potash ...	...	...	118	Superphosphate ...	...	...	435
				Sulphate of Potash ...	...	...	107
				Muriate of Potash ...	...	...	16
				Inert Material ...	...	...	256
Total ...	...	...	1,000	Total ...	...	...	1,000

These fertilisers were applied in alternate pairs of rows and the area was planted with five varieties so that half the number of plants of each variety was planted above each fertiliser. Close observation during growth failed to detect any

differences due to the two mixtures, and examination of the leaf during grading showed no difference in colour or texture. Samples of leaf from each mixture have been retained for smoking test.



Harvesting the tobacco leaf.

(Photo by A. Sharp.)

ROTATION EXPERIMENT.

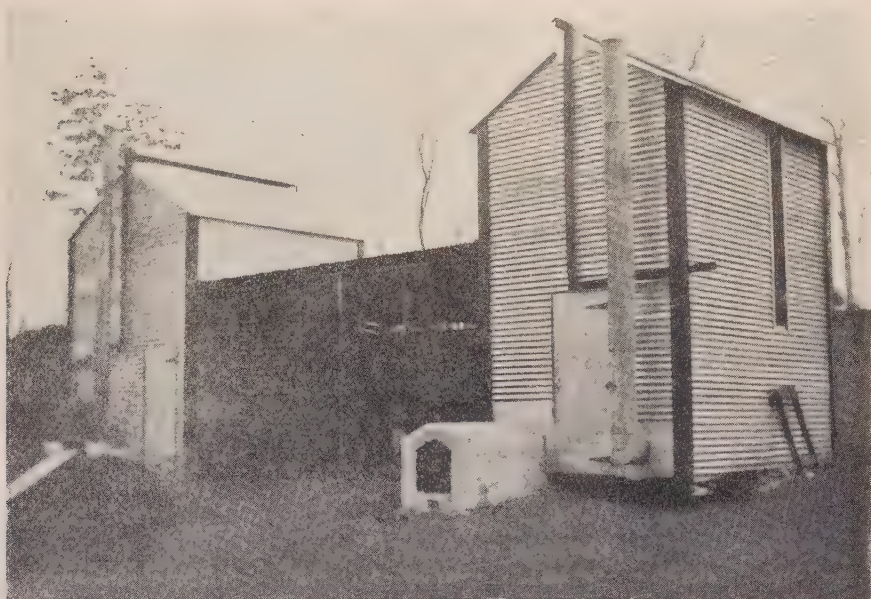
Part of the area at each station has been reserved for a long range rotation experiment. This has been designed to compare continuous cropping with tobacco against tobacco grown in two and three year rotations, and also to test the effect on yield and tobacco quality of various leguminous and non-leguminous fodder and green manure crops included in the rotation. As it is considered that tobacco growing should be carried on in conjunction with some other type of farming, such as sheep raising, dairying, etc., one object of this experiment is to determine how intensively suitable tobacco land can be farmed without detrimentally affecting the quality of tobacco leaf. It will, of course, be some years before an experiment of this nature can yield reliable information.

On completion of harvesting of the tobacco crop, the stalks were removed and burnt and the ground ploughed and cultivated. The rotation crops were sown with various winter growing crops in May. These included New Zealand and blue lupins, field peas and tick beans (legumes) and rye and rape (non-legumes). These plots, with the exception of the lupins which are not relished by stock, were fed off by sheep at Jardee and by cattle at Donnelly. They were then allowed to make some fresh growth before being ploughed in in August.

EXPLORATORY PLOTS.

While the tendency within recent years has been for tobacco growing to be confined to the Manjimup district, it is felt that tobacco leaf of acceptable quality might be grown in other parts of the South-West of the State. Accordingly, a number of small exploratory plots were planted in co-operation with settlers in

the Margaret River, Forest Grove, Karridale, Nornalup, Denmark, Albany and Mount Barker districts. The plots were planted in November. Each plot included two varieties, Cash and Kelly, and half received a dressing of standard tobacco fertiliser at the rate of 1,000 lbs. per acre, and the other half received the same treatment with the addition of small quantities of five minor elements, viz., zinc, copper, manganese, magnesium and boron. An inspection was made about five weeks after planting when it was found that those at Albany and Mount Barker had not made good growth and were obviously suffering from the dry conditions prevailing. Those in the remaining areas looked quite promising and were again visited during February when samples of mature leaf were picked and taken to Manjimup for curing.



Curing kilns and stringing shed at the Donnelly Research Station.

(Photo by A. A. Johnston, Manjimup.)

The cured leaf was placed in bulk until July when it was examined and tested for smoking quality. The results of the most promising plots are given below.

1. Grown by Mr. G. H. Doyle, Margaret River—

Leaf rather small but of good colour and fine texture. Good burn and quite good smoking aroma.

2. Grown by Mr. S. Robinson, Forest Grove—

Leaf of medium size, colour bright mahogany and mahogany with fine texture. The burn was fair and aroma fairly good. The addition of minor elements in this case appeared to have detrimentally affected the colour, texture and smoking quality of the Kelly leaf.

3. Grown by Mr. R. D. Matthews, Karridale—

This plot was fertilised with superphosphate only and growth was rather poor in consequence. Leaf was rather small but of good colour and soft texture. The burn was exceptionally rapid for Western Australian leaf and the smoking aroma more definite than typical Manjimup leaf.

4. Grown by Mr. E. J. Clarke, Walpole—

Leaf small and colour rather dark but texture good. Burn and smoking aroma both rather poor.

5. Grown by Mr. A. L. Chatley, Walpole—

Leaf small to medium size. Colour mahogany to dark. Fine texture. Burn and aroma rather poor.

6. Grown by Mr. R. J. Russell, Denmark—

Leaf rather small, fairly good colour and fine texture. Burn was rather poor and smoking aroma was fair except in the case of the Cash variety treated with minor elements which was pungent and unpleasant.



Baled tobacco leaf at the auction sale conducted by Dalgety and Co., at Fremantle, on September 2nd, 1940.

(Shipping Newspapers, Ltd.)

In assessing the results of these plots allowance must be made for the fact that all samples of leaf had to be taken long distances by car to Manjnap during very hot weather and were badly wilted before being placed in the curing barn, and also that they were cured along with larger and heavier bodied leaf. It is probable that the burn and aroma will improve somewhat after a period of maturation.

It is considered that the results obtained warrant further investigation of these districts.

The co-operation of the settlers on whose properties the plots were grown is much appreciated.

ACKNOWLEDGMENTS.

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Studies in Sheep Husbandry in Western Australia.

I.—THE EFFECT OF NUTRITIONAL "FLUSHING" UPON FERTILITY.

E. J. UNDERWOOD and F. L. SHIER.

It is of obvious economic importance to the farmer and grazier that his breeding stock should be maintained at their highest possible level of fertility. The fertility of the female animal—i.e., the ability to bear young—depends basically upon her ability to produce fully ripened ova at each oestrus period. In the ewe, as with other animals, the maximum number of ova shed at such times or the upper limit of fertility is determined genetically, i.e., by breed, though it can be appreciably influenced by selection. The age of ewes is also capable of affecting fertility as shown by Jones and Rouse (1920), Roberts (1921) and by Kelley (1939). The degree to which a ewe can give expression to its genetic possibilities with respect to fertility, however, is markedly affected by environmental factors. The nutritional conditions at the time of mating are especially important in this respect. This has been recognised for many years by British farmers as evidenced by their adoption of the practice of "flushing" to increase the lambing percentage in their flocks—Marshall (1904), (1908). Flushing consists essentially of the provision of extra feed, i.e., raising the plane of nutrition of the ewe for a short period immediately prior to mating, thus stimulating follicular development and favouring the maturation of a greater number of ova. It has also been claimed that flushing will bring the ewes into oestrus sooner than they otherwise would and thus restrict the period of lambing (Marshall & Hammond, 1926).

Studies of the lambing returns of the main British breeds of sheep obtained from 133 flocks in the British Isles were made by Nichols (1924). The ewes which had been flushed prior to mating produced an average of 149.5 lambs per 100 ewes compared with 124.6 lambs per 100 unflushed ewes. Returns from a considerably smaller number of sheep obtained in the following year (Nichols, 1926) showed a similar though less marked effect from flushing. An increased proportion of multiple births was considered to be the primary reason for the higher returns, though a correlation between barrenness and low percentage of twins was found.

Experiments carried out in U.S.A. over a period of five years by Marshall and Potts (1921) showed definite effects from flushing on the yield of lambs from Southdown ewes. The average lambing percentage from 125 ewes unflushed over the period was 128.8 compared with 146.9 per cent. lambs from 167 flushed ewes. This increase was due principally to an increased proportion of twins. The greatest effect of the flushing was obtained in those groups of ewes in the lowest condition at the commencement of treatment, i.e., where the greatest liveweight increases were brought about. The nature of the extra feeding given—i.e., whether cereal grain or green pasture or protein supplements, was found to be immaterial though it should be pointed out that the number of experimental animals from which these conclusions were drawn was exceedingly small.

An increased lambing yield from flushing has also been reported by Okulicev (1934) who obtained 103 per cent. lambs from the control ewes, whereas 120, 112 and 110 per cent. lambs were obtained from the flushed groups. Clark (1934) found no effect from flushing half of a group of 40 Shropshire ewes, i.e., no increase in the number of double ovulations, but a marked effect in a similar group

of merinos. This difference was attributed by the author to the lower plane of nutrition of the merino sheep at the start of the treatment. In neither breed did the flushed ewes come into oestrus any sooner than the unflushed.

It is clear from the above that flushing of ewes prior to service is capable of increasing lambing percentages, though the results appear to be widely variable and the amount of controlled experimental data with groups of ewes of adequate size is exceedingly small. This criticism applies particularly to merinos and merino crosses. In Australia where such breeds predominate, there appears to be no critical data at all on this question, a matter of considerable surprise in view of the importance of high fertility as a factor in reducing costs of production of wool and lambs. The lower inherent twinning capacity of the merino makes recommendations based on experiments carried out with other breeds in other parts of the world rather dubious, since all previous writers on the subject of "flushing," with the exception of Grant (1934), agree that the improvement of fertility is brought about primarily by increasing the proportion of twins.

It was therefore considered worth while initiating experiments in W.A. on this phase of animal husbandry so that quantitative data on the methods and results of flushing of merinos and merino crosses might be obtained. On most farms in the agricultural areas of Western Australia, not only is flushing not practised, but the reverse position, with respect to the nutritive status of the ewe at mating, all too frequently exists. Mating usually takes place in November and December, when the natural feed is drying off and consequently falling in nutritive value. Mating at this time is essential if the ewes are to lamb on green feed the following autumn. In other words, under the usual conditions of sheep husbandry practised in Western Australia, at the present time, the period immediately prior to service is one of a falling state of nutrition or the very reverse of that regarded as the most conducive to maximum fertility. It was decided to commence with an experiment on large groups of Merino X Border Leicester ewes since the British long-wool cross ewe forms the basis of the important export lamb industry in this State. A high percentage of twins would be exceptionally valuable in such ewes, not only because of their quality but because the milk yield of the mothers is unlikely to limit seriously the development and value of twins compared with singles, as is frequently stated to be the case with merinos. The present paper records the methods and results of this experiment. A similar study with pure merinos will form the subject of future investigations.

Location of Experiments.

The experiment was conducted at the Avondale Research Station, Beverley, situated some 60 miles south-east of Perth on the Great Southern Railway.

The climate is of the Mediterranean type, being characterised by a mild winter and spring—when most of the rainfall occurs and plant growth takes place—and a hot dry summer when there is little rainfall and no crop or pasture growth. The mean monthly rainfall (inches) for Beverley and the maximum and minimum temperatures (degrees F.) for York (the nearest temperature recording station 20 miles further north) are shown below.

—	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Rain	·31	·39	·72	·89	2·28	3·18	3·31	2·55	1·59	1·02	·47	·40	17·08
Max. Temp.	91·9	90·8	85·6	78·5	69·1	63·3	61·8	63·9	68·2	73·2	82·7	88·9	76·5
Min. Temp.	60·7	61·2	57·4	51·8	46·3	43·5	41·3	41·8	43·6	46·4	52·9	58·3	50·4

Experimental Procedure.

On 31/10/39 a flock of 700 first cross Merino-Border Leicester ewes were divided into two similar groups by alternate drafting. Equal age distribution in each group was obtained by "mouthing" and dividing the flock into the various age groups prior to drafting. The age distribution within each main group is shown in Table 1.

TABLE 1.
AGE DISTRIBUTION WITHIN GROUPS.

							Age in Years.	Group A.	Group B.
Full mouth	...	...	...	...	...	...	$4\frac{1}{2}$ - $5\frac{1}{2}$	90	91
6-tooth	...	...	...	...	...	...	$3\frac{1}{2}$	82	80
4-tooth	...	...	...	...	...	...	$2\frac{1}{2}$	129	130
2-tooth	...	...	...	...	...	...	$1\frac{1}{2}$	49	49
Total	....	...	...	...	...	...	...	350	350

The treatment to be given to the two groups (Group A—flushed; Group B—unflushed) was determined by tossing a coin.

TREATMENT.

(A Group—flushed): On the following day (1/11/39) this group was placed in a 40-acre paddock which had previously been heavily grazed and contained comparatively small quantities of dry pasture made up principally of dry-headed barley grass (*Hordeum murinum*) cluster clover (*Trifolium glomeratum*) and other poor annual clovers. During the month which the sheep were maintained on this grazing they were weighed four times and showed an average live weight loss over the period of 7 lbs. per head. The process of flushing was commenced on 1/12/39 when the group was transferred to a 100-acre paddock carrying good dry grazing consisting of self-sown oats and subterranean clover. In a fortnight the sheep gained an average of 2 lbs. live weight per head. They were then (15/12/39) mated with 10 Southdown rams and placed in another paddock containing fresh oaten stubble and a fair quantity of mature unharvested field peas, where they began to gain weight rapidly. In a fortnight they had gained an average of a further 14 lbs. per head and another 7 lbs. per head in the subsequent fortnight i.e., up to 18/1/40. The live weight gains and losses both in this group and in Group B are shown in Table 2.

TABLE 2.
AVERAGE LIVE WEIGHTS OF GROUPS IN LB.

	31-10-39.	10-11-39.	22-11-39.	30-11-39.	13-12-39.	4-1-40.	18-1-40.
Group A. (Flushed)	108.0	102.3	100.7	100.9	102.8*	116.4	123.1
Group B. (Unflushed)	108.2	107.8	107.7	107.7	107.3*	100.3	97.9

* Rams placed with ewes.

Group B—"Unflushed." On 1/11/39 this group was placed in a paddock of 80 acres which contained some mature barley and dry annual grasses and clovers. On this grazing the ewes barely maintained their live weight during the following

six weeks, i.e., up to 15/12/39, when they were mated with 10 Southdown rams. In the subsequent fortnight they lost an average of 7 lbs. live weight per head (see Table 2) and a further 2-3 lbs. in the following fortnight. Although the live weight losses were only 10-11 lbs. per head during this whole period, the ewes appeared weak and in poor condition. On 26/1/40 they were therefore transferred to a large cereal stubble paddock containing much better dry grazing.

Early in March Group A was also placed in this paddock and similar treatment given to both groups throughout pregnancy. They were run as one flock until the end of April but during most of the lambing period the groups were separated in order to simplify the work of obtaining lambing details.

During the lambing period the flocks were inspected daily and all ewes which had lambled were recorded and removed with their lambs to other paddocks. Details were recorded also of deaths of ewes at lambing, lambs born dead or died before removal from the main flock, as well as those killed by foxes. After lambing was completed the remaining ewes, which included those whose lambs had died or been killed, were examined and a check made of the number of ewes which had not conceived.

RESULTS.

The lambing results from the two groups are shown in Table 3.

TABLE 3.
LAMBING RESULTS.

	Group A. (Flushed)	Group B. (Unflushed)	Remarks.
Ewes mated	350	350	
Ewes surviving until lambing period ...	349	349	
Deaths of ewes during lambing period ...	7	7	All pregnant—in A. Group 4 ewes carrying twins.
Lambs born dead, or died just after birth ...	6	5	
Lambs killed by foxes	14	7	
Pairs of twins removed with their mothers ...	63	8	} Highly significant* P = >0.1.
Singles removed with their mothers	257	303	
Total removed with their mothers	383	319	
Total lambs born	403	331	
Percentage lambs born	114.6	94.6	
Number of ewes which conceived	337	330	Not significant.*

* Significance determined by Fisher's X^2 Test.

It is apparent from the table that the flushing has had a marked effect on the number of pairs of twins produced. Thus 63 pairs of twins were removed with their mothers from Group A compared with only eight pairs from Group B. A further examination of the data shows that the effect was even more marked than these figures suggest. In the B group there were apparently no twins other than the eight pairs just mentioned. In A Group, however, four ewes of the eight that died before lambing carried twins. An examination of the total figures, including the lambs killed by foxes, indicates that at least a further four ewes must have produced twins. In all at least 71 pairs (20%) of twins were conceived in Group A compared with eight pairs (2%) in Group B.

The total number of lambs removed with their mothers from the lambing paddocks was 383 (109.4%) in Group A and 319 (91.1%) in Group B, whilst the figures on the basis of the number of lambs conceived (i.e., including lambs born

dead, lost at birth or immediately afterwards by accident) were 414 (118.3%) and 338 (96.6%) respectively. It is evident that the higher lambing in the flushed group is, in this experiment, entirely due to the greater incidence of twinning since the difference in the number of ewes which conceived in each group (337 in Group A and 330 in Group B) is not significant.

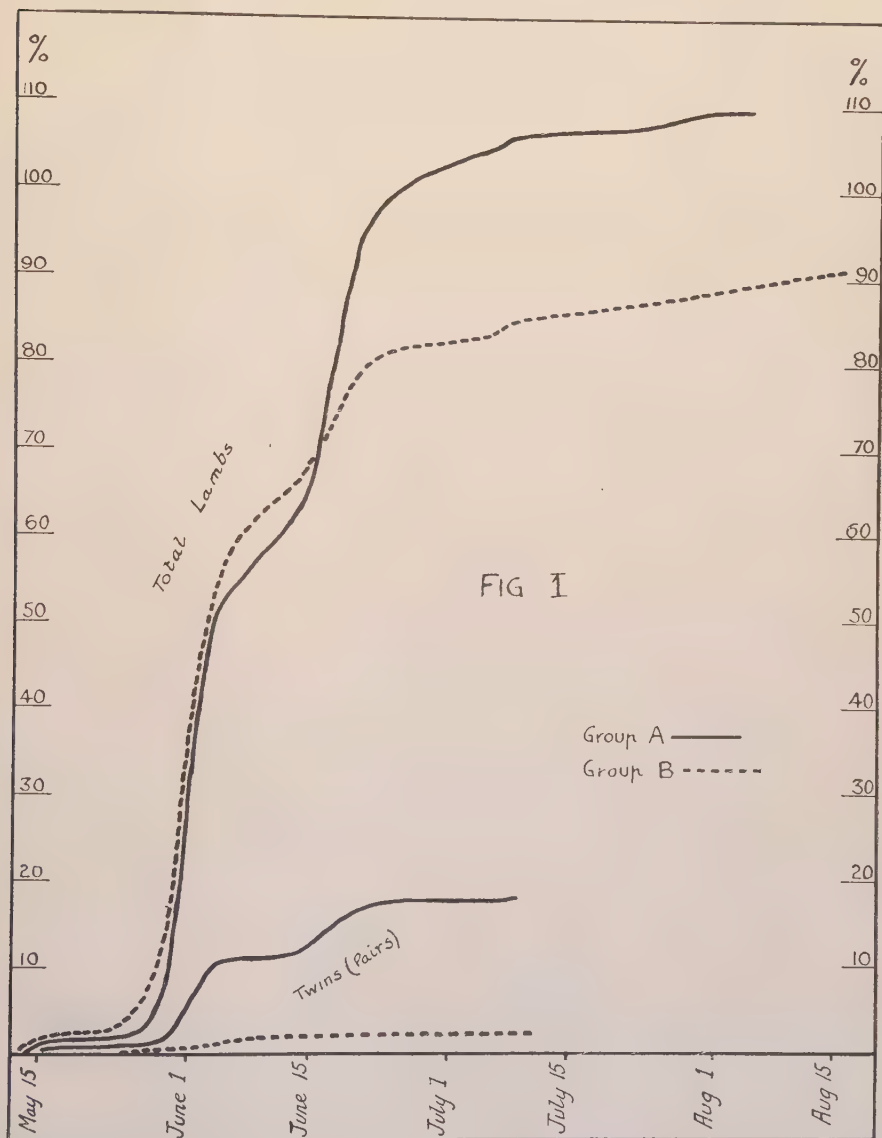


Figure 1.—Graph showing the progressive total lambing (singles and twins) and the pairs of twins in each group, expressed as a percentage of the original number of ewes mated.

The progressive lambing percentages are represented graphically in Figure 1. This graph is based on the number of lambs removed with their mothers from the lambing paddocks, expressed as a percentage of the original number of ewes mated in each group (350).

Several interesting points are made clear by the graph. In the first place it is evident that, with the exception of an odd lamb, lambing did not commence in either group until a fortnight after the expected date. In the second place it is clear that, despite the greater number of twins in Group A, the *total* lambing percentage does not exceed that in Group B until 15th June, about two weeks after the main lambing had commenced. Moreover, the actual number of ewes lambed at any date is significantly higher in Group B than in the flushed group until 22nd June.

The rate and the times of lambing are shown again in Fig. II, where the number of ewes lambing daily in each group is presented in diagrammatic form and also the number of ewes producing twins daily in Group A. The later lambing of the ewes in the flushed group, already mentioned, is made very clear in this graph. It is apparent also that the lambing in both groups has taken place in two definite modes, with the interval between approximating a normal di-oestrus period.

It will also be noted that the time of appearance of the twins was very similar to that of the singles, i.e., the flushing had no effect in bringing about a greater percentage of twins early in the season, as has been suggested by Marshall and Hammond (1925).

DISCUSSION.

The pronounced influence of flushing treatment on the lambing percentages, through its effect in increasing the proportion of twins to singles is abundantly clear from the material already presented and calls for little further comment.

There are a number of other points of both practical and theoretical interest, however, which arise from the experiment and warrant further discussion.

The actual manner of flushing is of particular interest in this respect. No hand-feeding was carried out and no special green feed or high protein concentrates made available. The ewes were flushed on good oaten and pea stubble reserved for the purpose and such as might be available on any farm in similar districts. Whether the peas present in the grazing, with their high protein content played any significant part in the flushing or whether the oaten stubble alone would have been equally effective it is at present impossible to say. This question of the nature or quality of the feed used in flushing will form the subject of a future investigation, particular consideration being given to the protein factor in view of the special importance which is frequently attributed to this nutrient. It is felt, however, that the quality of the feed used in flushing is likely to be of secondary importance within limits, to its quantity and to the condition of the ewes prior to flushing. It should be stressed that in the present experiment the ewes were definitely brought down in condition, by restricted grazing, prior to flushing, while the ewes of the unflushed group were allowed to maintain themselves in good, but not overfat, condition. In the month following the start of flushing and preceding the start of active mating, on the other hand, the flushed group rose from an average of 101 to 116 lbs. live weight, while the unflushed group fell from 108 to 101 lbs. during the same period. It is suggested that the mere addition of more food to animals already well fed and in fat condition is not likely to be very successful though it has been frequently carried out both in practice and in experiments and has been designated flushing. Under the usual conditions of sheep husbandry as practised in the agricultural area of Western Australia, the sheep are turned out on to the best grazing for the year after shear-

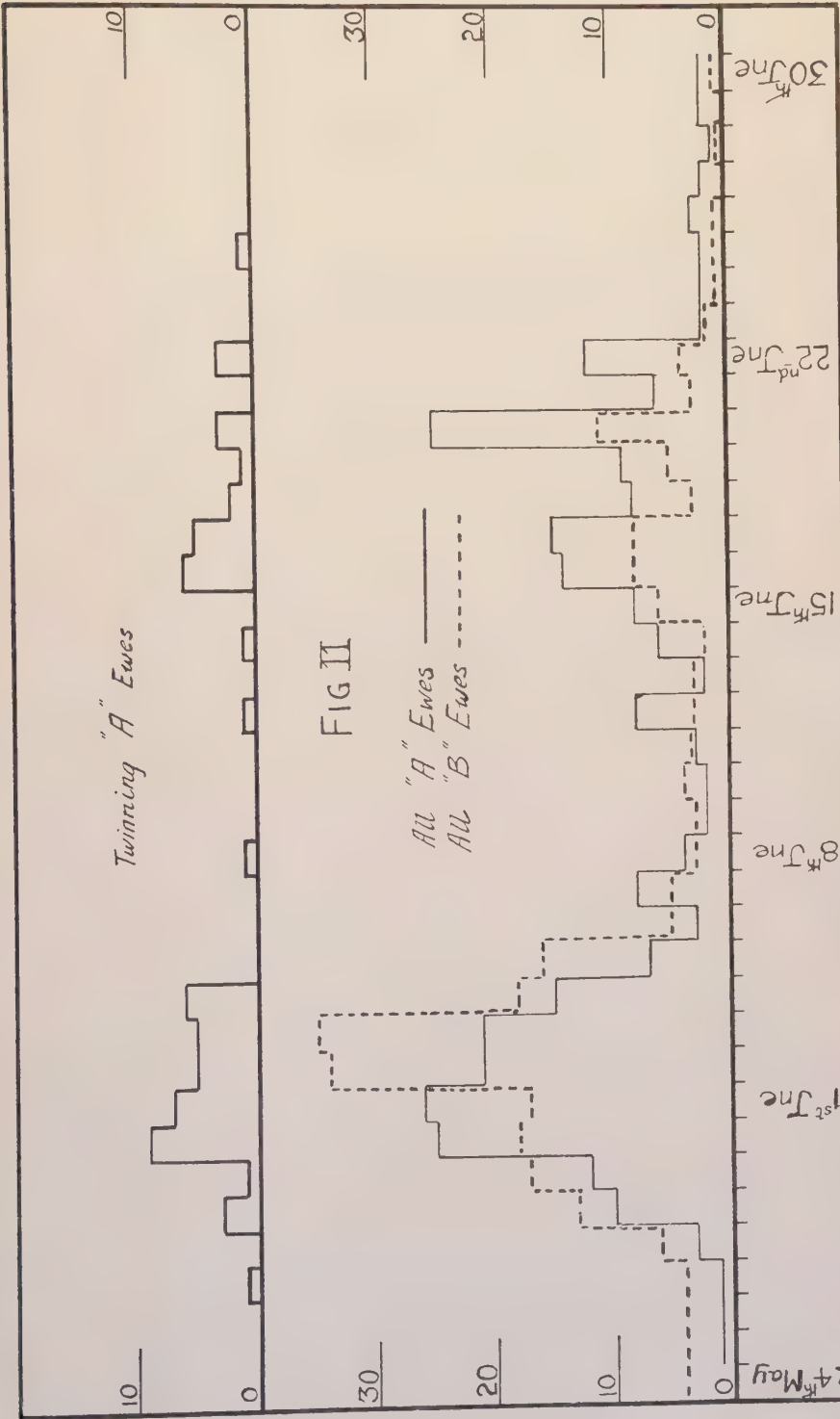


Figure II.—This figure shows the total number of ewes (single and twin births) lambing daily in each group and also the number producing twins in Group A.

ing in September. They put on condition rapidly at this time and only begin to lose weight in November and December when the pasture is drying off and falling in nutritive value, and before the stubble becomes available. It is at this time that mating takes place, that is when the sheep are in a falling, instead of the rising state of nutrition which must be regarded as most conducive to maximum fertility. It should be easily possible to reverse this state of affairs, as shown in the present experiments, by intelligent management of the sheep and grazing and with no added expenditure to the farmer.

The finding that the effect of flushing on fertility is primarily through an increased proportion of multiple births (in this case twins) bears out the finding on other breeds in other parts of the world. Any other *positive* effect was hardly possible in the present experiment since practically 95 per cent. of the ewes conceived even in the unflushed group. A correlation between barrenness and low percentage of twins, as found in the studies of Nichols (1926), was thus virtually ruled out. Speculation on the probable or possible effects of flushing with pure merinos is stimulated, however. Although the lower inherent incidence of twinning in this breed would appear to reduce the chances of success, yet the higher degree of barrenness in ordinary merino flocks, which is suggested by the lower average lambing percentages, opens up some possibility through raising the proportion of ewes which conceive.

The influence of flushing on the time and period of lambing is of considerable interest in view of the statement sometimes made that such treatment brings them into oestrus earlier; and the claim of Marshall and Hammond (1926) that it restricts the period of lambing. In the present experiment it is evident that the total period of lambing is closely similar in the two groups (Fig. 1). In regard to the times of lambing it is clear from Fig. 2 and from figures given earlier, that there is actually a small but definite lag in Group A (flushed) compared with Group B. This is in line with the finding of Marshall and Potts (1924) that there were more cases of ewes returning for a second and third service in the flushed groups than in the unflushed. This is surprising and the possibility that the rams influenced this delay in Group A cannot be entirely neglected. They were in very good condition before being joined with the ewes. The extra nutriment provided for the flushed group (A), which was of course equally available to the rams, may have tended to make them too fat and sluggish for active work. This could not have been a factor in the case of the rams joined with the ewes of Group B. The failure of the flushing to bring about earlier lambing in Group A bears out the finding of Roux (1936) and of Kelley (1939) that the plane of nutrition has, in the main, no influence on the incidence of oestrus.

Two further points with respect to the times of lambing are brought out in Figs. I. and II. and deserve brief mention here. There are—first, the delay of about two weeks after the expected time (i.e., just five months after joining the rams with the ewes) before active lambing began to take place and, second, the occurrence of lambing in two definite peak periods, with the intervening interval approximating to a normal di-oestrus cycle. At first sight these appear unrelated observations and the temptation is to explain the first in strictly practical terms such as failure of the rams to “get going,” or the ewes not yet being in season. From the periodic incidence of oestrus, with two peaks of intensity recurring at approximately a 17-day interval, for this flock as indicated from Fig. II, it might be argued that the time when the rams were first placed with the ewes (i.e., the middle of December, 1939) coincided with the previous “trough” of the oestrus incidence

curve. Not until 14-15 days later did the ewes begin to come rapidly into oestrus and a peak in such a curve appear. Rhythmic fluctuations in the daily lambing incidence appear to occur regularly, judging by the previous records of several groups of sheep examined by the writers. It is intended to make this highly interesting question the subject of further study and publication at a later date.

SUMMARY.

An experiment designed to test the effect of nutritional flushing on the fertility of first cross Border Leicester x Merino ewes in Western Australia is described.

A flock of 700 such ewes was divided into two groups of 350 with an equal age distribution in each group. One group (A) was first brought down in condition by restricted grazing and then flushed on to good quality dry oaten and pea stubble on which they rapidly gained in weight. The flushing commenced four weeks prior to the beginning of active mating and continued during the mating period. In contrast the other group (B) was provided with dry grazing which first just maintained their condition and then reduced it prior to and during the mating period.

It was found that the flushing treatment produced a highly significant increase in fertility. This was brought about entirely through an increase in the proportion of twins. The lambing percentage (i.e., lambs reared) of the flushed group was 109.4, including 63 pairs of twins (18%). The corresponding figures for the unflushed group were 91.1% and eight pairs of twins (2%).

The flushing did not bring the ewes into oestrus any earlier, had no effect in restricting the period of lambing, nor did it induce a greater percentage of twins during the first part of the lambing season.

A number of practical and theoretical considerations arising from the experiment are discussed.

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Termites or "White Ants."

By C. F. H. JENKINS, Government Entomologist.

INTRODUCTION.

Termites are commonly but erroneously called "White Ants." Actually they are more nearly related to cockroaches than they are to ants, but their general appearance and subterranean habits have given strong support to the popular designation. They may be divided into two major groups from an economic point of view, viz., *Wood dwelling* and *Earth dwelling* Termites.

The *wood dwellers* enter wood directly from the air, and often the colony is wholly confined to the particular piece of timber in which it is working, but with the *Earth Dwellers* the conditions are somewhat different.

Earth dwelling termites destroy wood by attacking it from the ground or from another piece of timber in contact. The main colony is situated underground and they often build tubes or covered runways from the ground over wood plaster, etc., to wood at higher levels. It is to this earth dwelling group of termites that the principal economic species in Australia belong and consequently it is against them that our control measures are levelled.

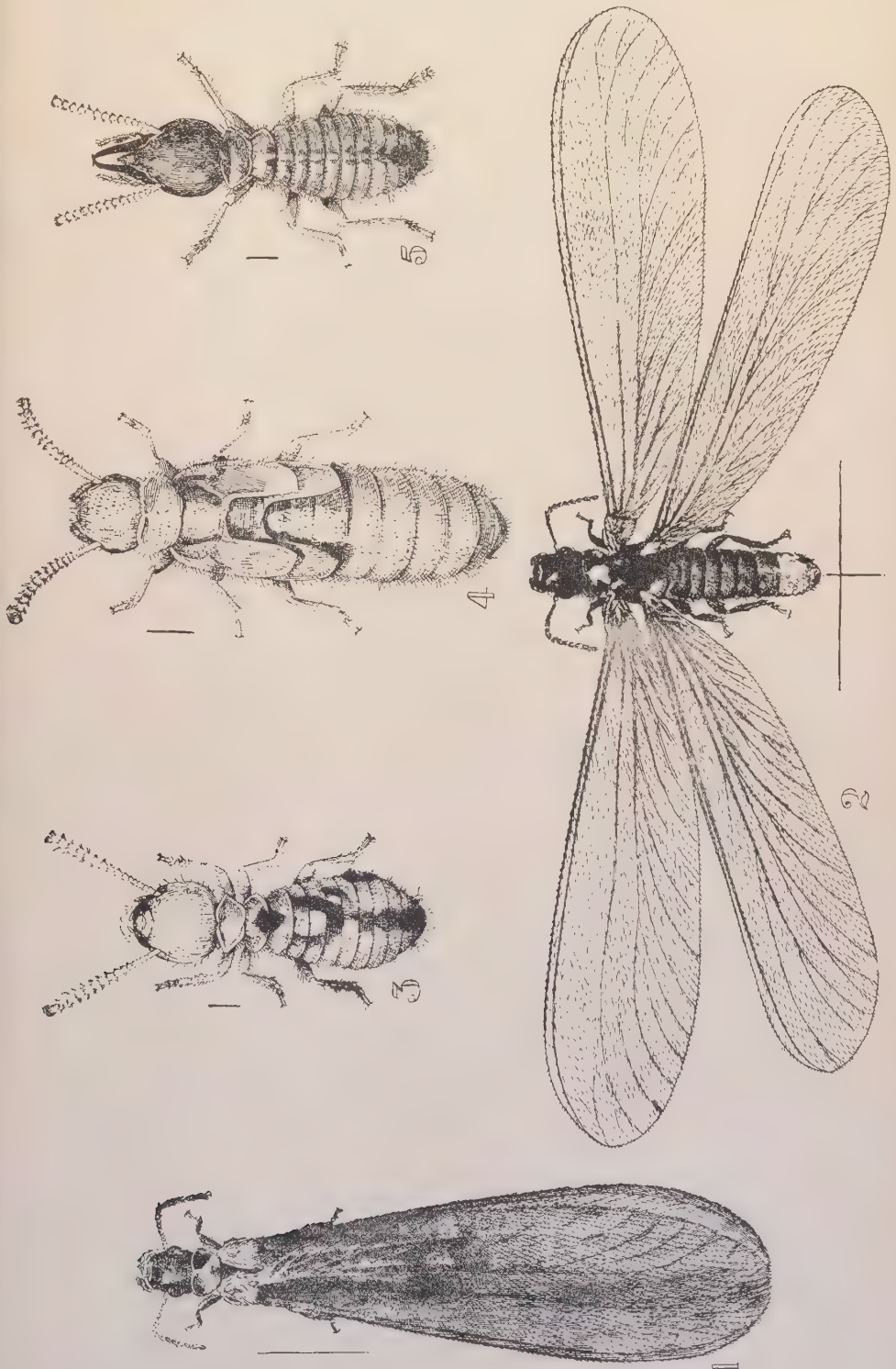
LIFE HISTORY.

Like ants and bees, the termites are social insects with specially developed types or castes. Again, as in the case of ants and bees, the vast majority of individuals are *workers* who have the duties of food getting, construction and care of the young. A small percentage of individuals have their jaws greatly enlarged, not for gnawing wood, but to serve as weapons, and these large headed, strong-jawed members of the community are termed *soldiers*. When a gallery wall is breached by an enemy, it is the soldiers' duty to protect the colony until the damage has been repaired by the workers. In some of the higher groups of termites a different type of soldier is met with. The jaws are very poorly developed, but the fore-part of the head is produced into a prominence or rostrum, and a corrosive milky fluid is exuded from a pore at the apex. This fluid serves as a very effective weapon of defence, and being acid in nature, is responsible for the etching of metals traversed by termites, and makes the penetration of lime and mortar possible. This particular type of soldier is known as a *nasute soldier*.

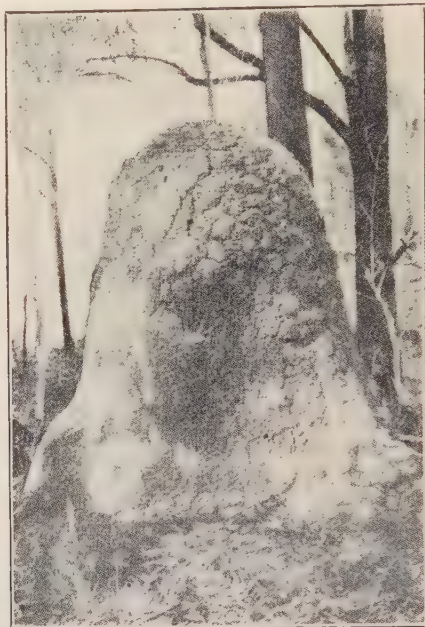
The *Royal pair* are solely interested in perpetuating the race and although when first starting a colony they have a multitude of duties to attend to, after the first brood of young has developed, the queen assumes massive proportions, and becomes little more than an animated egg-laying machine.

The *swarming* of termites has been observed by everyone. This is merely the emergence of the winged males and females preparatory to forming new colonies. Warm, humid weather is usually chosen for the flight which is only of short duration. The wings are then shed, pairing takes place, and the couple burrow into the soil near some log or stump to commence the task of founding a new colony.

Termites react negatively to light, and so will only work in the dark. They are also very sensitive to desiccation and thrive best in a humid atmosphere. Both these facts are important in considering some of the control measures recommended.



1 & 2, Male and Female Winged Termites; 3, Worker; 4, Nymph; 5, Soldier. [After Frognall.]



Domed Nest.

[After Froggatt.]

PREVENTIVE AND CONTROL METHODS.

Resistant Timber.

All timbers are not equally attractive to termites, and consequently where possible termite-resistant timber such as Jarrah (*Eucalyptus marginata*) Native Pine (*Callitris spp.*), Jam (*Acacia acuminata*) and American Red-wood (*Sequoia sempervirens*) should be used for building or fencing.

Treatment of Timber.

Coal-tar creosote has been found the most effective medium with which to treat timber against termite attack.

The immunity obtained varies according to the method of treatment and the degree of penetration of the chemical. The *Pressure Process* is the most effective, but as the timber is subjected to vacuum treatment, it is not applicable to general usage, and need not be enlarged upon here.

The *Open Tank Process*, which merely involves dipping timber likely to be buried or in contact with the soil, is a method which is readily usable. If the creosote is heated and the timber allowed to steep for some hours until the mixture has cooled down, a better penetration will result than from a cold dip, but even the painting or spraying of timber, especially if several times repeated, will give protection.

Water-Soluble Preservatives

Where timber is not exposed to wet conditions, a dip consisting of Arsenite of Soda, 1 lb. to 2 gallons, or a strong solution of White Arsenic may be used. (As White Arsenic is difficult to dissolve in cold water, the mixture should be boiled and stirred.)

Precautionary Measures for Buildings.

Prior to building, the ground should be thoroughly cleared of all stumps, roots and timber likely to harbour termites. As little timber as possible should be in contact with the soil, and then only if suitably treated. Piers and piles supporting the floor should be capped with metal such as zinc or galvanised iron.

Control.

When termites are known to be working in a building, the most effective control will be obtained by the use of *poisonous dusts*. White Arsenic, Paris Green or Sodium Fluosilicate (Sodium Silico-fluoride) may be used.

The method of application is to bore holes into the infested timber or gently prize open a crack with a knife or screwdriver and puff into the galleries a small quantity of the dust, using a small rubber powder-blower or a dust-gun. Treatment should be given at a number of different places according to the extent of the infestation, and the bore holes and cracks should be carefully plugged or pasted over. This latter is essential, for if the holes are sealed the insects will continue to use the treated galleries, but if the holes are left open to admit the light the termites will block off the damaged galleries and desert them, only to carry on work elsewhere.

The amount of dust to be injected will vary according to the size of the timber being treated, but one ounce should be enough for about 20 or 30 holes. The main essential is to introduce the dust into the termite galleries while causing as little disturbance to the insects as possible. The termites themselves, by running backwards and forwards over the dust will be the main factor in ensuring its wide distribution. Death is caused by the insects grooming and cleaning themselves and one another, and so swallowing some of the poison.

These poisonous dusts will only prove effective when finely ground and when used in dry situations. Moisture soon clogs and cakes them, and in this respect Sodium Fluosilicate is more susceptible to moisture than Arsenic or Paris Green.

After treating the timber it should be left undisturbed for a month or more, in order that the dust may take effect, then any very badly damaged parts may be replaced.

Where possible the nest should be located and dug up. It may be under the house or many yards away, but it should be treated by drenching with creosote and similarly the ground around any "doubtful" parts could be saturated with creosote or creosote and kerosene, or even sump-oil.

Ground Treatment.

In addition to creosote, saturated solutions of Copper Sulphate (Bluestone) or Borax have been found effective if liberally watered into the soil. They cannot be used, of course, on soil wanted for cultivation.

Fruit Trees and Garden Plants.

The requirements for controlling termites in fruit or flower gardens and buildings are fundamentally the same. In clearing the land preparatory to planting, care should be taken to remove all stumps and timber liable to harbour the pest. Avoid injuring the trees as much as possible, as dead roots or scars near the ground induce attack. Badly infested trees should be removed, but the poison

dust treatment has often been used to save trees and vines not too far gone. Holes should be bored into the infested trunk just above ground level, and the dust blown in. Any limbs which can be got at may be similarly treated.

In the case of the vine, dust injected into the pithy centre of the trunk, where termites sometimes work, has been found by New South Wales entomologists to be quite effective. As in dead timber, all bore holes should be plugged with grafting wax or some such material.

Where the roots of a plant are attacked, the use of a fumigant such as *Para-dichlorobenzene* is suggested. A trench three or four inches deep should be dug about six or nine inches from the base of the plant and scattered with two ounces of fumigant. After filling in, the gas will gradually disseminate into the soil. This treatment will not be effective in soil saturated with water, and will be more effective when the soil is warm.

Poison Baits.

Poison baits have been claimed by some to give encouraging results, and so the following formula is quoted, although the use of this method is only advised in conjunction with the other more universally proved recommendations, and not as an alternative.

Heat together 1 lb. of molasses and $\frac{1}{4}$ lb. of sugar. To this add 1 ounce of Arsenite of Soda dissolved in $\frac{1}{2}$ a cup of boiling water.

This sticky bait should be smeared on soft-wood boards attractive to termites, and two boards with treated sides touching so as to form a sandwich should be buried in the ground near where termite activity is suspected.

SUMMARY.

1. Principal economic species in Western Australia belong to the earth-dwelling group.
2. Treat all timber in contact with the soil with Coal-tar Creosote.
3. Carefully clear land of old roots, etc., before building or planting trees.
4. Isolate piers and building piles from timber above with metal caps.
5. Treat infested timber or trees by blowing poison dust into the insect galleries.
6. Plug carefully all cracks and bore holes made during dust treatment.

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Toxic Paralysis (Botulism).

In the December *Journal* appeared an article under the above heading. The Department would be pleased to receive samples of about 2 or 3 lbs. of fodder, etc., which circumstances indicate may be responsible for the disease in horses. Previous work has been largely confined to sheep and, to a lesser degree, cattle. As pointed out in the *Journal* we have not yet determined the type of toxin certainly responsible for the disease in horses, and cannot therefore be sure that the botulinous toxoid is efficacious for them.

When sending samples kindly send a covering letter describing the symptoms encountered and full particulars of the outbreak.

Fertilisers.

H. G. CARISS, Assistant Inspector of Fertilisers.

Owing to war time conditions the supplies of fertilisers in this State have to some extent been limited, this applying especially to nitrate of soda, sulphate of ammonia and potassic fertilisers. The short supply of these ingredients has of necessity caused some alteration in the formulae of the mixed manures from their former percentage composition. Sulphate of potash in particular is at present difficult to obtain and in some cases the muriate has to be used in its place, either wholly or in part.

In addition, as would be expected from increased freight rates and insurance, the cost of practically all fertilisers has increased considerably and hence, with the exception of the organic fertilisers, the unit values of the different ingredients are higher than for former years.

The unit values for the different ingredients in their various forms, based on prices at the time of registration, have been calculated and are tabulated below. These unit values are a guide to purchasers for the comparison of similar fertilisers only, e.g., two blood and bones or two potato manures but not between a blood and bone and a potato manure.

UNIT VALUES.

	1937-38.	1938-39.	1939-40.	1940-41.
Nitrogen (N) as—	s. d.	s. d.	s. d.	s. d.
Dried blood	...	...	26 0	23 6
Blood and Bone, Bonedust ...	23 0	24 0	22 4	21 9
Bone and Flesh	...	...	...	...
Nitrate	18 1	18 1	18 1	19 9
Ammonia	11 3	11 2	11 11	15 11
Phosphoric Acid (P ₂ O ₅) as—				
Water Soluble as Superphosphate	3 3	3 3	3 3	4 5
Citrate Soluble as Superphosphate	3 3	3 3	3 3	4 5
In Blood and Bone, Bonedust, and other organic fertilisers ...	5 9	6 0	5 7	5 5
Basic Phosphate	4 11	4 11	4 11	6 3
Acid Soluble in Superphosphate and Rock Phosphate ...	2 2	2 2	2 2	2 11
Potash (K ₂ O) as—				
Sulphate	6 5	6 5	6 5	8 0
Muriate	5 7	5 7	5 7	7 0

The following Fertilisers have been registered at the Department of Agriculture under the Fertilisers Act, 1928, for the year commencing 1st November, 1940:—

Name of Fertiliser.	Reg. No.	Brand.	By whom Registered.	Nitrogen (N) as :				Phosphoric Acid (P ₂ O ₅) as :				Potash (K ₂ O) as :		Cash Price per ton on Rail at Works or Perth.	
				Ni- trate.	Am- monia.	Blood and Bone	Bone- dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sul- phate.	Muri- ate.		
A.—MINERAL.															
1.—NITROGENOUS.															
(a)—Nitrogen as Nitrate—															
Nitrate of Soda	31	Cresco	Cresco Fertilisers (W.A.), Ltd.	15.50	...	...	...	...	...	...	...	...	...	W 15 6 6	
Do.	50	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.	15.50	...	...	...	...	...	...	...	...	...	W 15 6 6	
Do.	69	ML in diamond	do.	15.50	...	...	...	...	...	...	...	...	...	W 15 6 6	
Do.	89	CSML	do.	15.50	...	...	...	...	...	...	...	...	...	W 15 6 6	
(b)—Nitrogen as Ammonia—															
Sulphate of Ammonia	26	Cresco	Cresco Fertilisers (W.A.), Ltd.	...	20.50	...	...	...	...	...	...	...	...	W 16 11 0	
Do.	32	I.C.I.A.N.Z.	Nitrogen Fertilisers Pty., Ltd.	...	20.60	...	...	...	...	...	...	...	...	W 16 11 0	
Do.	48	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.	...	20.50	...	...	...	...	...	...	...	...	W 16 11 0	
Do.	68	ML in diamond	do.	...	20.50	...	...	...	...	...	...	...	...	W 16 11 0	
Do.	88	CSML	do.	...	20.50	...	...	...	...	...	...	...	...	W 16 11 0	
Do.	95	BHP	Nitrogen Fertilisers Pty., Ltd.	...	20.60	...	...	...	...	...	...	...	...	W 16 11 0	
Do.	107	MG Co. in diamond	do.	...	20.59	...	...	...	...	...	...	...	...	W 16 11 0	
2.—PHOSPHATIC.															
(a)—Rock Phosphate—															
Pacific Islands Phosphate	46	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.	...	...	...	...	...	...	36.65	36.65	...	...	W 5 7 0	
Phosphate Powder	24	Cresco	Cresco Fertilisers (W.A.), Ltd.	...	...	...	...	...	...	36.65	36.65	...	...	W 5 7 0	
Pacific Islands Phosphate	66	ML in diamond	Cuning Smith & Mt. Lyell F.F., Ltd.	...	...	...	...	...	...	36.65	36.65	...	...	W 5 7 0	
Do.	86	CSML	do.	...	...	...	...	...	...	36.65	36.65	...	...	W 5 7 0	
(b)—Superphosphate—															
Florida Superphosphate, 22%	33	Sickle	Cresco Fertilisers (W.A.), Ltd.	...	...	...	...	20.50	.50	1.00	22.00	...	...	W 4 18 6	
23 Super.	13	Cresco	do.	...	...	...	...	21.25	.50	1.25	23.00	...	...	W 4 18 6	
Florida Superphosphate, 23%	34	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.	...	...	...	...	21.25	.50	1.25	23.00	...	...	W 4 18 6	
Superphosphate, 22%.....	53	ML in diamond	do.	...	...	...	...	20.50	.50	1.00	22.00	...	...	W 4 18 6	
High Grade Super. 23%	54	do	do.	...	...	...	...	21.25	.50	1.25	23.00	...	...	W 4 18 6	

	73	CSML	do.	do.	20-50	1-00	22-00	W 4 18 6
	74	do.	do.	do.	21-25	.50	23-00	W 4 18 6
Superphosphate, 22% High Grade Super., 23%								
(c)—Rock Phosphate and Superphos- phate—								
Phosphate Mixture, 50/50	65	ML in diamond	do.	Cresco Fertilisers (W.A.), Ltd.	10-00	.50	18-50	W 5 7 6
50/50 Phosphate	23	Cresco	do.	Cresco Fertilisers (W.A.), Ltd.	10-00	.50	18-50	W 5 7 6
Phosphate Mixture, 50/50	45	Sickle	do.	Cuning Smith & Mt. Lyell F.F., Ltd.	10-00	.50	18-50	W 5 7 6
Phosphate Mixture, 50/50	85	CSML	do.	do.	10-00	.50	18-50	W 5 7 6
(d)—Basic Phosphate—								
Basic Phosphate	44	Sickle	do.	do.			17-00	W 5 6 0
Do.	64	ML in diamond	do.	do.			17-00	W 5 6 0
Do.	84	CSML	do.	do.			17-00	W 5 6 0
3.—POTASSIC.								
(a)—Potash as Sulphate—								
Sulphate of Potash	10	Palestine	George Wills & Co. Ltd.					W 19 7 6
Do.	27	Cresco	Cresco Fertilisers (W.A.), Ltd.					W 19 7 6
Do.	49	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.					W 19 7 6
Do.	70	ML in diamond	do.	do.				W 19 7 6
Do.	90	CSML	do.	do.				W 19 7 6
(b)—Potash as Muride—								
Muriate of Potash	11	Palestine	George Wills & Co. Ltd.					\$
Do.	25	Cresco	Cresco Fertilisers (W.A.), Ltd.					W 17 7 6
Do.	51	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.					W 17 7 6
Do.	71	ML in diamond	do.	do.				W 17 7 6
Do.	91	CSML	do.	do.				W 17 7 6
4.—NITROGEN AND PHOSPHORIC ACID.								
Super. and Ammonia, 6 : 1	19	Cresco	Cresco Fertilisers (W.A.), Ltd.		17-50	.50	19-00	W 7 7 0
Do.	20	do.	do.		15-37	.37	16-50	W 8 11 6
Do.	21	do.	do.		13-66	.34	14-66	W 9 11 0
Do.	* 40	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.		17-50	.50	19-00	W 7 7 0
Do.	41	do.	do.		15-37	.37	16-50	W 8 11 6
Do.	42	do.	do.		13-66	.34	14-66	W 9 11 0
Do.	60	ML in diamond	do.		17-50	.50	19-00	W 7 7 0
Do.	61	do.	do.		15-37	.37	16-50	W 8 11 6
Do.	62	do.	do.		13-66	.34	14-66	W 9 11 0
Do.	No. 1	CSML	do.		17-50	.50	19-00	W 7 7 0
Do.	No. 2	do.	do.		15-37	.37	16-50	W 8 11 6
Do.	No. 4	do.	do.		13-66	.34	14-66	W 9 11 0
Do.	No. 2	do.	do.		17-50	.50	19-00	W 7 7 0
Do.	No. 4	do.	do.		13-66	.34	14-66	W 8 11 6
Potato Manure, No. 1	14	Cresco	Cresco Fertilisers (W.A.), Ltd.		17-50	.50	19-00	W 7 7 0
Do.	" C "	Sickle	Cuning Smith & Mt. Lyell F.F., Ltd.		17-50	.50	19-00	W 7 7 0
Do.	No. 2	ML in diamond	do.		17-50	.50	19-00	W 7 7 0
Do.	" C "	CSML	do.		17-50	.50	19-00	W 7 7 0

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as			Phosphoric Acid (P ₂ O ₅) as			Potash (K ₂ O) as		Cash Price per ton on Rail at Works or Perth.		
				Ni- trate.	Am- monia.	Blood and Bone.	Bone- dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.		Sul- phate.	Muri- ate.
5.—POTASH AND PHOSPHORIC ACID.														
Super. and Potash	47	Sickle	Cuning Smith & Mt. Lyle F.F., Ltd.	...	...	...	...	17.00	.25	2.75	20.00	6.30	...	W 7 5 0
Do.	67	ML in diamond	do.	...	...	...	...	17.00	.25	2.75	20.00	6.30	...	W 7 5 0
Do.	87	CSML	do.	...	...	...	...	17.00	.25	2.75	20.00	6.30	...	W 7 5 0
6.—NITROGEN, PHOSPHORIC ACID AND POTASH.														
Potato Manure, "B"	36	Sickle	do.	...	3.00	...	...	16.25	.50	1.00	17.75	2.40	...	W 8 1 0
Do.	37	do.	do.	...	3.00	...	...	15.00	.50	2.00	16.50	4.80	...	W 8 17 0
Orchard Manure "E"	38	do.	do.	...	2.05	...	...	17.00	.50	2.00	19.50	2.50	...	W 7 10 6
Special Mixture "K"	33	do.	do.	...	4.10	...	...	13.50	.50	2.00	16.00	5.00	...	W 9 6 0
Tobacco Fertiliser	43	...	do.	...	3.30	...	...	14.00	.50	1.00	15.50	5.70	...	W 9 11 0
Potato Manure, No. 3	56	ML in diamond	do.	...	3.00	...	...	16.25	.50	1.00	17.75	2.40	...	W 8 1 0
Do.	57	...	do.	...	3.00	...	...	17.00	.50	2.00	19.50	2.50	...	W 8 17 0
Orchard Manure	59	do.	do.	...	2.05	...	...	13.50	.50	2.00	16.00	5.00	...	W 7 10 6
Special Mixture "K"	58	do.	do.	...	4.10	...	...	14.00	.50	1.00	15.50	5.70	...	W 9 6 0
Tobacco Fertiliser	63	do.	do.	...	3.00	...	...	16.25	.50	1.00	17.75	2.40	...	W 8 1 0
Potato Manure, "E"	76	CSML	do.	...	3.00	...	...	15.00	.50	2.00	16.50	4.80	...	W 8 19 0
Do.	77	do.	do.	...	2.05	...	...	17.00	.50	2.00	19.50	2.50	...	W 7 10 6
Orchard Manure	79	do.	do.	...	4.10	...	...	13.50	.50	2.00	16.00	5.00	...	W 9 6 0
Special Mixture "K"	78	do.	do.	...	3.00	...	...	14.00	.50	1.00	15.50	5.70	...	W 9 11 0
Tobacco Fertiliser	83	do.	do.	...	3.30	...	...	16.25	.50	1.00	17.75	2.40	...	W 8 1 0
Tomato Manure	109	do.	do.	...	3.00	...	...	13.50	.50	2.00	16.00	5.00	...	W 9 6 0
Potato Special	16	Cresco	Cresco Fertilisers (W.A.), Ltd.	...	3.50	...	...	14.00	.50	1.00	15.50	5.70	...	W 9 11 0
Potato Manure, No. 2	15	do.	do.	...	3.00	...	...	15.00	.50	1.00	16.50	4.80	...	W 8 17 0
Orchard Manure	18	do.	do.	...	2.05	...	...	16.25	.50	2.00	19.50	2.40	...	W 8 1 0
Special Orchard	17	do.	do.	...	4.10	...	...	13.50	.50	2.00	16.00	5.00	...	W 9 6 0
7.—MISCELLANEOUS.														
Super. and Manganese*	29	Cresco	do.	...	...	...	...	17.00	.50	1.00	18.50	...	...	W 7 17 6
Super. and Copper, No. 1	110	Sickle	Cuning Smith & Mt. Lyle F.F., Ltd.	...	...	...	...	20.00	.50	1.00	21.50	...	...	W 7 5 0
Do.	111	ML in diamond	do.	...	...	...	...	20.00	.50	1.00	21.50	...	...	W 7 5 0
Do.	112	CSML	do.	...	...	...	...	20.00	.50	1.00	21.50	...	...	W 7 5 0
Super. and Copper	113	Cresco	Cresco Fertilisers (W.A.), Ltd.	...	...	...	...	20.18	.47	1.19	21.84	...	...	W 7 5 0
B.—ORGANIC.														
(a) Blood and Bone—Animal Fertiliser	4	State Abattoirs, Midland Junction	State Abattoirs, Midland Junction W. Angliss & Co. (Aust.) Pty., Ltd.	...	...	8.00	...	...	...	5.00	5.00	...	...	W 9 5 0
Blood and Bone	2	Riverstone	do.	...	...	5.50	...	...	...	9.25	14.25	...	...	P 12 0 0

Do.	6	Eclipse	W.A. Meat Export Co., Ltd.	6-00	...	...	...	...	...	12-00	12-00	12-00	...	...	W9 12 6
Do.	7	Robbs	do.	5-25	...	...	...	...	...	14-00	14-00	14-00	...	...	W9 7 6
Do.	8	TB&S in diamond	Thomas Borthwick & Sons (Aust.), Ltd.	5-75	...	...	...	...	...	6-00	11-75	11-75	...	...	7 0
Do.	9	Apollo	J. Kitchen & Sons Pty., Ltd.	...	...	...	...	...	...	...	14-00	14-00	...	...	(F.O.B. Melbourne)
Do.	25	Cresco	Cresco Fertilisers (W.A.), Ltd.	7-00	...	...	...	...	...	...	12-00	12-00	...	...	P10 10 3
Do.	52	Sickle	Cuming Smith Mt. Lyell F.F., Ltd.	6-25	...	...	...	...	...	...	15-00	15-00	...	...	W11 0 0
Do.	72	ML in diamond	do.	5-00	...	...	...	...	...	...	15-00	15-00	...	...	W10 0 0
Do.	92	CSML	do.	5-00	...	...	...	...	...	...	15-00	15-00	...	...	W10 0 0
Do.	93	do.	do.	5-00	...	...	...	...	...	...	15-00	15-00	...	...	W10 10 0
Do.	97	AI in circle	Haynes & Clements	6-00	...	...	...	...	...	...	12-00	12-00	...	...	W11 0 0
Do.	99	P/B B	Paton, Burns & Co.	5-25	...	...	...	...	...	...	9-00	12-00	...	...	11 5 0
Do.	103	ANA Surprise	C. A. Kirkby & Sons	5-25	...	...	...	...	...	...	10-00	12-00	...	...	...
Do.	104	Wyndham	Wyndham Meatworks	5-00	...	...	...	...	...	...	10-00	14-00	...	...	...
Do.	106	Apex	W.A. Produce Co.	5-75	...	...	...	...	...	...	9-00	15-00	...	...	11 15 0
Do.	108	Wooltana	Modra Honann Wooltana Fertilisers, Ltd.	5-60	...	...	...	...	...	...	13-00	13-00	...	...	P10 5 0
				6-00	...	...	...	...	...	...	10-00	10-00	...	...	P10 12 6
(b) Bones—															
Bonedust	5	Eclipse	W.A. Meat Export Co., Ltd.	...	...	...	...	3-50	...	...	22-00	22-00	...	...	W7 10 0
Do.	30	Cresco	Cresco Fertilisers (W.A.), Ltd.	...	...	...	...	3-50	...	...	22-00	22-00	...	...	W9 15 0
Do.	94	CSML	Cuming Smith Mt. Lyell F.F., Ltd.	...	...	...	...	3-50	...	...	22-00	22-00	...	...	W9 10 0
(c) Nitrogenous—															
Nitrogenous Fertiliser (8% Nit.)	96	Nitrome	Paterson & Co., Ltd.	8-00	...	...	...	...	...	...	...	...	...	...	F11 5 0
Dried Blood	1	Fitzroy	W. Angliss & Co. (Aust.) Pty., Ltd.	13-00	...	...	...	...	...	...	...	...	...	...	P16 15 0
Do.	3	Riverstone	do.	13-00	...	...	...	...	...	...	...	...	...	...	P17 5 0
Do.	98	Sun	Westralian Farmers, Ltd.	11-00	...	...	...	...	...	...	...	...	...	...	W9 10 0
(d) Fish—															
Fish Guano, No. 1	100	Corno	M. F. Phillips	...	...	...	...	4-00	...	...	18-00	18-00	...	...	W9 7 6
Do.	101	do.	do.	...	...	...	...	5-25	...	...	14-00	14-00	...	...	W10 10 0
(e) Guano	102	do.	do.	...	...	...	...	2-00	...	...	22-50	22-50	...	...	W6 5 0
C.—MINERAL AND ORGANIC.															
Manurial Insecticide	12	Kill-a-Mite	Thomas Agency	...	...	...	...	1-00	...	...	3-76	3-76	...	...	P19 10 0
Bone Super and Potash	22	Cresco	Cresco Fertilisers (W.A.), Ltd.	...	...	...	...	...	...	...	14-00	14-00	...	...	W5 8 0
Fertos	105	Floreat	T. S. McGill	...	...	...	...	...	...	...	1-55	17-05	...	...	W22 10 0

*Contains 5.75% manganese as MnO₂ †As hoof and treated leather.

Chenopodium Oil.

WORMSEED, A USEFUL LOCAL WEED.

C. A. GARDNER, Government Botanist.

There is, at the present time, a shortage of *Chenopodium* oil, the price of which has increased lately, and the presence of this plant in fair quantities in the littoral areas of the South-West between Perth and Bunbury makes the possibility of local production promising.

The plant in question, known as "Wormseed," or locally as "Ant weed" is *Chenopodium ambrosioides* L., var. *anthelminticum*, and is cultivated in the United States, principally in Maryland and South Dakota, as well as in the Dutch East Indies. It is a perennial herb, the leaves, flowers and fruits of which contain an oil characterised by a strong scent resembling that of formic acid. This scent is very pronounced in the dried plant, or when the young green parts are bruised. The plant is native to Mexico where the leaves have been used in place of tea, and thus it is sometimes referred to as Mexican tea. From Mexico it spread in early times to South America, where it was used medicinally, and it is now established in several countries. The date of its introduction into Australia is unknown, but it has probably been established in the vicinity of Perth for at least a century.

The whole plant contains more or less of the volatile oil which is most abundant in the young shoots, flowers and seeds. This oil is more or less retained in the dried plant. The American aborigines used the whole plant in decoction in painful menstruation, and its use as a vermifuge has been known from early times. It is this use that probably accounts for its introduction into Brazil at a very early date, for in the collection of specimens made by Dampier nearly three hundred years ago, specimens of this plant were collected in Brazil.

Wormseed furnishes the important drug *Chenopodium*, official in the United States, and included in the British Pharmacopeia. It is used as a vermifuge in man and animals, being used for the expulsion of lumbricoid (round) worms, especially in children, and in veterinary medicine for a similar purpose in pigs and poultry. It is regarded as being perhaps the most valuable of all the vermifuge remedies because of its low toxicity, its efficacy, and the ease of its application.

It is also employed against tapeworm, and is used in veterinary practice in a worm mixture for dogs, combined with oil of turpentine, oil of aniseed, castor oil and olive oil.

Chenopodium oil was first isolated by a German pharmacist in Brazil in 1895, in which country the seeds of the plant had long been in use under the name of *Herba Sancti Mariae* in pectoral complaints, as an expectorant in catarrh and asthma. In 1912, two Dutch physicians working at Deli, in the Dutch East Indies, stated that the essential oil of *Chenopodium* was the most effective remedy known against ankylostomiasis—the hook-worm disease. Originally this disease was exclusively tropical and subtropical, but about forty years ago it made its appearance amongst mine workers in Europe north of the Alps. Several remedies have been tried against hookworm, thymol appeared to be the remedy used with most success, but oil of *Chenopodium* gives better results than thymol, eucalyptus or beta-naphthol. The use of *Chenopodium* oil commenced commercially in the early years of the last war when thymol was not available. It proved to be satisfactory in every way, and statistics show that after three treatments, about 95 per cent. of the worms are removed from the body. In Fiji it has proved an anthelmintic of great potency, and it is stated there that over 80 per cent. of the worms are expelled

after a single dose. The observances of Schuffner and Vervoot have been confirmed by other medical men, and *Chenopodium* oil is now the recognised remedy for hookworm disease.

The principal constituent of *Chenopodium* oil is ascaridole, as much as 60 to 70 per cent. being present in the oil. Ascaridole is an unstable substance, allied to cineol, and readily decomposed on heating, with the production of a hydrocarbon. It also contains glycol and safrol, amongst other principles, and the powerful effect of the oil is ascribed to the combination of ascaridole and safrol. The fresh plant yields the alkaloid chenopodine, a white tasteless and odourless crystalline powder.

The commercial oils contain markedly varying quantities of ascaridole, and the amount lessens with keeping. Overdoses of the freshly distilled oil have been known to cause symptoms of poisoning. It is desirable that commercial oil should be labelled with ascaridole content, and the date of distillation.

In place of the oil, the fresh plant can be used: the bruised fruit may be given in doses of 20 grains, in the form of an electuary; a fluid extract is prepared, of which the dose is half to one drachm, and the expressed juice of the plant is also employed in doses of one tablespoonful.

Wormwood or ant weed is a common weed of waste lands in Perth and its environs, and is found at various spots to the south as far as Bunbury, e.g., Mandurah, Pinjarra, Lowden, Bunbury and Busselton. Tests in progress by a Perth commercial firm interested in the plant show that the quality of the oil is suitable, but the initial tests made with the whole plant (much of which consisted of stems) gave a yield of .4 per cent. A much higher yield is expected from younger parts of the plant, especially when in seed. A description of the plant is given hereunder, together with a sketch showing its habit, flowers and fruits. There are two plants yielding *Chenopodium* oil in quantity, *Chenopodium ambrosioides* L., which is an annual with sinuately lobed leaves, and the official variety *anthelminticum* which is a strong perennial with more deeply toothed leaves. This character of the lobing of the leaves is however variable, and in the variety *anthelminticum* it is the lower leaves of the plant that are of diagnostic importance, together with the perennial habit.

DESCRIPTION OF PLANT.

A perennial herb of two to three or more feet in height, with erect or ascending stems from a woody stock, the stems striate and angular; leaves alternate, petiolate, tapering into the petiole at the base, acute or acuminate, the lowest the largest, coarsely dentate, the uppermost almost entire, soft, minutely glandular-hairy, pinnately veined, oblong-lanceolate to lanceolate in outline; flowers small, in small globular clusters in the axils of small floral leaves along slender axillary spikes, the whole forming a terminal leafy panicle; floral leaves oblong or obovate-spathulate to almost linear; perianth green, five-lobed, the lobes rounded-ovate and obtuse, rounded on the back; stamens five, exserted, filaments white, thin, dilated towards the base; anthers dorsifixed, two-celled; ovary whitish, globular, glandular-papillose at the summit; styles two or three; fruit enclosed in the perianth, obovoid to depressed-globular, the pericarp thin; seeds reddish-brown, smooth and shining, thickly lenticular with a narrow ridge on the border, erect or horizontal; embryo curled round the mealy endosperm.

The generic name is derived from the Neo-Latin form of the Greek *Khenopous*—*Khen*, a goose, *pous*, a foot, hence the vulgar name "Goosefoot" for species of *Chenopodium* in general, one of which is the so-called Mexican Spinach: the specific name *ambrosioides* refers to the resemblance of the plant to some species of *Ambrosia*.



WORMSEED.

Chenopodium ambrosioides L., var. *anthelminticum*.

A, rootstock; B, upper part of branch; C, leaf; D, flower cluster showing floral leaf and flowers; E, flower bud; F, the same with one perianth-segment removed; G, stamens and pistil; H, fruit and seeds. *Icon origin.*

Infectious Entero-toxaemia ("Braxy-like Disease," "Pulpy Kidney") of Sheep in Western Australia.

C. R. TOOP, Chief Veterinary Surgeon.

INTRODUCTION.

Among the diseases which affect sheep in Western Australia none is of greater economic importance than infectious entero-toxaemia. It is responsible for heavy, though largely preventable, annual losses, principally sustained during that period of the year when green feed is available. This disease has been known to exist in Western Australia for more than 25 years, the earliest records of its occurrence dating back to 1915. Originally it was confined to the Great Southern districts being centred around Beverley and it consequently became known as "the Beverley sheep disease." With the expansion of agriculture and the cultivation and cropping of farm lands the disease has steadily spread from that centre and at the present time practically the whole of the agricultural districts of the State are involved. The losses were at first thought to be associated with the consumption of poison plants. This view, however, could not be substantiated. Dakin, who investigated the disease during 1918, suspected its infectious nature and in describing it used the name "braxy-like" disease on account of a certain resemblance which he recognised between it and braxy—a disease affecting sheep in Great Britain and parts of Europe. The similarity between these diseases lay in the fact that in both of them death occurred suddenly preceded by symptoms of such short duration as to frequently pass unnoticed and that subsequent to death the carcase putrefied and became bloated with gas with extreme rapidity. Apart from this the two conditions are quite dissimilar. The term "braxy-like" disease has, however, persisted to the present day and it is still widely employed by sheepmen.

It remained for Dr. H. W. Bennetts of this Department to demonstrate the true nature of the condition. In 1931 he was able to show that a micro-organism commonly present in the soil of cultivated lands was responsible for its occurrence. Under certain conditions, as yet not clearly understood, this organism was able to multiply in the small intestine of the sheep and to produce a powerful toxin or poison, the absorption of this toxin being responsible for the death of the animal. Bennetts named this organism *Bacillus ovitoxicus* and for the disease adopted the name infectious entero-toxaemia which very appropriately describes it, i.e., a disease resulting from the absorption of a bacterial toxin from the small intestine. Having isolated the organism responsible he was able to prepare from it a vaccine—now known as entero-toxaemia vaccine—which, upon being injected into a sheep, thereafter conferred upon it an immunity which would protect it against the disease. Bennetts' findings were of far reaching importance and upon their publication it soon became apparent that "pulpy kidney" disease, often responsible for severe mortalities amongst young lambs particularly in New Zealand, as well as certain of the braxy-like diseases of Eastern Australia, New Zealand and other countries were identical conditions and could be similarly controlled.

CONDITIONS UNDER WHICH THE DISEASE MAY OCCUR.

The great majority of the outbreaks of infectious entero-toxaemia occur between the months of April and October coinciding with that period of the year when green feed is available. Losses may be sustained at any time during this

period but they do not tend to follow any regular sequence fluctuating from property to property, season to season and district to district. Records kept during the course of one season showed them to have been as low as 1 per cent. on some properties and to have approached 30 per cent. on others. A property may be affected during one season and escape altogether during the next. Moreover, it is commonplace to find mortality occurring on one property while those adjoining it remain entirely free.

The greatest losses from infectious entero-toxaemia occur in seasons of heavy rainfall resulting in a prolific growth of green feed. During 1939, which was a year of record rainfall, the heaviest mortalities so far experienced in this State occurred. In many instances the losses commence soon after the advent of green feed or perhaps a little later on towards the middle of the season and continue to occur at irregular intervals until the feed dries off in late spring. This is probably the most frequent course taken by the disease. These losses are usually intermittent in character, a few sheep being found dead in the paddocks at irregular intervals. In the aggregate, however, the mortality may reach serious proportions by the time the end of the season is reached. In some districts it is unusual for deaths to commence before August or September but here again the total losses may be quite heavy until they are checked by the drying off of the feed. Sometimes sudden and severe mortalities occur, a large number of sheep dying within the space of a few days. Sheep dying during the course of an outbreak of infectious entero-toxaemia are rarely noticed ailing. Usually their carcasses are found lying in the paddocks, most often in the mornings, being highly distended with gas, discoloured and undergoing rapid putrefaction.

LOSSES UNDER DRY FEED CONDITIONS.

Although the losses from infectious entero-toxaemia predominate when green feed is available and it must almost essentially be regarded as a disease of the "flush" season, it is not wholly confined to this period and mortalities may occur when sheep are being depastured on dry feed. Such mortalities are principally associated with the consumption of flowering stinkwort which acts as a predisposing factor, and they occur during late summer and autumn when feed is scarce and the plant is freely eaten. A considerable number of severe mortalities have been recorded under such conditions and they are especially likely to occur in those years in which the dry season is unduly prolonged owing to the late arrival of the winter rains. In addition infectious entero-toxaemia has been observed during the dry period of the year amongst flocks running on peas, on wheat crops which have not been harvested owing to storm damage or poorness of yield, and where a ration of concentrates has been fed. The disease has also been observed in the case of sheep running on coarse dry feed such as stubble but mortalities under the latter circumstances appear to be of rare occurrence in this State.

TYPE OF SHEEP AFFECTED.

Sheep of all breeds and ages are susceptible to the disease and in the majority of outbreaks the losses appear to be fairly evenly distributed throughout the flock. In this State, however, lambs do not usually become affected until reaching the age of eight or 10 weeks which contrasts sharply with the position in New Zealand and parts of Eastern Australia where the heaviest mortalities amongst lambs occur during the first month of life. In some instances the disease may affect principally the grown sheep of the flock while in others it may be almost entirely

confined to the lambs. This latter circumstance *might* be explained by the assumption that in those districts where the disease has existed for a number of years the grown sheep from frequent exposure to infection have developed a natural immunity, as the result of having become affected by the disease in a mild form from which they have recovered. No such immunity is enjoyed by the lambs. It might also explain why the mortality rate may be high when the disease first appears in a district and tends to steadily diminish during subsequent seasons.

Sheep in fat condition are most frequently affected and attention has constantly been directed to this feature particularly in the case of mortalities occurring during the "flush" season. This is not, however, invariably the case. On occasions mortalities have been observed amongst sheep in store condition and when the condition of the animals could only be described as poor. As a matter of fact when mortalities occur during late summer the sheep are frequently in such condition. Losses have also been observed in poor conditioned sheep during winter when the green feed is short and closely grazed.

THE CAUSE OF THE DISEASE.

The disease is caused by a rod-shaped micro-organism which occurs with great frequency in the soils of cultivated lands in which it is able to grow and to persist for long periods by the formation of spores. Originally designated by Bennetts as *Bacillus ovitoxicus* this organism has since been classified as *Clostridium Welchii* Type D. Owing to its wide distribution this organism must frequently be ingested by sheep during grazing but under ordinary conditions it passes through the intestine of the animal without producing any ill effects. Under conditions favourable to its growth, however, the organism is able to multiply rapidly in the small intestine of the animal at the same time producing a powerful toxin or poison. The absorption of this toxin from the intestine is responsible for the development of the disease. Bennetts has shown this condition which favours the growth of the organism to be a temporary stasis or sluggishness of the bowel. During his investigations he was unable to reproduce the disease experimentally by drenching sheep with cultures of the organism unless he first administered drugs which had the effect of slowing down the movement of the bowel. Until this procedure was adopted all attempts to reproduce the disease by drenching with cultures had failed. Just how this sluggishness of the bowel is brought about under natural conditions is not clearly understood. It is, however, known that certain feeding conditions predispose towards the disease and it is presumed that they are instrumental in setting up the bowel condition above described.

THE PREDISPOSING FACTORS.

Fibre and Exercise.—Green feed is the principal predisposing factor. This material, particularly when the growth is young and luxuriant, is low in fibre and high in moisture content. Moreover, under such conditions the sheep is able to obtain its food requirements with a minimum of exertion. It is well known that both fibre and exercise are powerful stimulants to bowel activity. Where these factors are lacking or not fully operative it would be reasonable to expect that a slowing down of the bowel movements (diminished peristalsis) would result thus setting up a condition favouring the development of the disease. Similarly in the case of sheep depasturing on dry peas or fallen grain or receiving a supplementary ration of concentrates all of which are low in fibre content the same factors would operate.

INJURY TO THE BOWEL WALL.

When infectious entero-toxaemia occurs in association with the consumption of stinkwort the predisposing factor appears to be the injury inflicted upon the bowel wall by the small barbed hairs attached to the developing seeds of this plant. Upon post mortem examination immense numbers of these hairs are found adhering to the lining membrane of the bowel often being so numerous in the small intestine as to form a feltwork covering a large area of its surface. The damage so inflicted apparently produces a set of conditions favourable to the growth of the organism in the bowel contents.

No explanation has been advanced to account for mortalities occurring under conditions where the feed is dry and coarse

THE SYMPTOMS.

An outstanding feature of the disease is the short duration of the symptoms, death occurring so rapidly after their onset that affected animals are rarely noticed ailing. In the majority of instances they are found dead in the paddock, the carcase generally being distended with gas and showing evidence of putrefactive changes. In the case of those animals actually noticed ailing the following symptoms will be observed. In the early stages the animal lags behind the flock moving about with its nose to the ground, often chewing excitedly at such objects as small stones, pieces of stick, etc. The gait is weak and unsteady, the animal from time to time knuckling over on its fetlocks or going down on its knees. Champing of the jaws may be observed and occasionally there is a discharge of frothy saliva from the mouth. Soon after the animal goes down usually lying on its side with the head turned in towards the left flank. From this stage it rapidly sinks into a condition of coma and dies quietly often without shifting its position. Death generally occurs within three or four hours after the first appearance of symptoms. In some, but by no means all cases, diarrhoea is a well marked symptom. The animal scours profusely, the excretions which are liquid and of unpleasant odour soiling its breach. In some cases affected sheep may linger from 24 to 48 hours before death occurs. In the early stages such animals may appear stupid and disinclined to move away when approached, wandering about aimlessly and blundering blindly into any obstacle which may cross their path. Occasionally in lambs, more rarely in grown sheep, convulsions may be observed. The animal apparently in normal health is suddenly seized by convulsions. It falls to the ground lying outstretched on its side with the head turned back making violent struggling movements until death supervenes two or three hours later. Finally what may be described as a mild or chronic form of the disease has been observed in which the affected sheep loses condition, and scours profusely. Animals showing these symptoms may survive for a week or longer. Many of them may recover.

THE POST MORTEM APPEARANCES.

When a post mortem examination is carried out immediately after death extremely few changes will be observed in the fresh carcase, the tissues and organs for the most part being normal in appearance. Slight changes, however, are usually present, the most constant of these being subendocardial haemorrhages which appear as rather large bluish blotches on the inner surface of the heart when that organ is opened for examination. Similar though much smaller haemorrhages may also be observed on the epicardium or outer surface of the heart. The small intestine may be somewhat distended with gas and its contents reduced in quantity. The blood vessels which supply it may be congested, appearing more prominent than usual. Few other changes of importance are present.

POST MORTEM DECOMPOSITION OF THE CARCASE—"PULPY KIDNEY."

Putrefaction commences immediately following death and continues to occur at an extremely rapid rate thereafter. After lying for three or four hours the carcase will usually have become greatly bloated and the wool may be plucked from it without difficulty. Parts such as the inner surfaces of the thighs and forearms which do not carry a covering of wool will be noticed to be discoloured, frequently being of a purplish hue. On opening the carcase the intestines will be found to be highly distended with gas and the extent of the putrefactive changes which have already occurred in the internal organs will be apparent. The kidneys in particular undergo very rapid decomposition. When the covering of fat is removed from these organs they will be found to have lost their well defined shape and to be composed of a soft pulpy mass of dark red tissue. It was on account of this pulpy condition that infectious entero-toxaemia became popularly known as "pulpy kidney" disease.

DIAGNOSIS OF INFECTIOUS ENTERO-TOXAEMIA.

A consideration of the history of the mortality, the symptoms, and the post mortem findings will usually enable a diagnosis to be established. Where deaths are occurring suddenly and irregularly, particularly during the winter months, and this is followed by rapid post mortem decomposition of the carcase the presence of the disease may be suspected. Supporting evidence will be obtained if it is possible to observe the symptoms exhibited by an affected animal. If in addition the kidneys are found to be characteristically degenerated and pulpy upon opening the carcase a few hours after death a diagnosis of infectious entero-toxaemia will in most instances be justified.

EXAMINATION OF SMALL BOWEL CONTENT.

The diagnosis can be definitely confirmed by the laboratory examination of the contents of the small intestine. The microscopic examination of such material will show the causal organism—*Cl. Welchii* Type D—to be present in great abundance. Furthermore, if the contents of the small intestine are filtered and a small quantity of the filtrate is injected into a laboratory animal the death of the animal will rapidly ensue. Material obtained from normal sheep or sheep affected by other conditions produces no such ill effects.

COLLECTION OF SMALL BOWEL CONTENTS.

This material should be collected immediately after the death of the animal. It is of no value for diagnostic purposes unless obtained from freshly dead sheep. The small intestine should be tied at its junction with the fourth stomach and again where it joins the caecum or blind gut and then freed from its attachments. By drawing the intestine through the thumb and forefinger its contents may be forced to one end and thence transferred to a wide mouthed bottle; a few drops of chloroform (.5c.cs. per 100 c.cs. of contents) being added as a preservative. This material should then be forwarded to the Veterinary Pathologist, Department of Agriculture, Perth, for examination and as it loses toxicity with age it should be despatched without delay. Suitable bottles containing the preservative may be obtained from the Department upon application.

PREVENTION OF INFECTIOUS ENTERO-TOXAEMIA.

Prior to the time when it became possible to control infectious entero-toxaemia by vaccination various expedients were employed for the purpose of preventing the losses for which the disease was responsible. Among these may be mentioned

the practice of shifting the sheep from paddock to paddock at frequent intervals, of transferring them to scrub country and of supplementing the grazing with food material high in fibre content such as chaff or hay. The former method was generally employed and while it succeeded in checking or reducing the mortality in some instances it failed completely in others. Such successful results as were obtained were probably due to the stimulant effect of exercise or change of diet upon the bowel movements. A change to scrub country will check the mortality completely presumably on account of the high fibre content of this material and the resultant stimulus to bowel activity. This procedure, however, is frequently impracticable and in any case it is not in the best interests of fat lamb or wool production. The feeding of supplements high in fibre content (chaff, hay, etc.), is designed to produce the same effect but the results obtained are so uncertain that they render this practice unworthy of serious consideration.

PREVENTION BY INOCULATION WITH ENTERO-TOXAEMIA VACCINE.

Inoculation with entero-toxaemia vaccine provides the only method of preventing the disease which is both practical and effective. This vaccine is prepared from cultures of *Cl. Welchii* Type D—the organism responsible for the disease—which are grown in the laboratory and then killed and rendered harmless by the addition of formalin. A sheep inoculated with this product will, after the elapse of about 14 days, develop a strong immunity which will enable it to resist the disease when exposed to infection. When first introduced it was necessary to administer this vaccine in two injections in order to obtain a satisfactory result; a small sensitising dose being followed by a second and larger immunising dose after a period of four weeks had elapsed. Recently the vaccine has been greatly improved by the addition of alum which results in the formation of a precipitate or deposit causing the vaccine to be very slowly absorbed from the site of injection and thus provoking a more powerful immunity response. The alum precipitated vaccine confers upon the treated animal a much higher degree of protection than does the “old type” unprecipitated product, consequently its use is now generally recommended. The degree of immunity conferred by it is such that a single injection will frequently give satisfactory results thus enabling the product to be used as a vaccine of the “one shot” type. A “one shot” vaccine has the obvious advantage of reducing costs in labour and material which the double handling of the flock would otherwise involve.

Since the greatest losses from the disease occur during the winter and spring months it is recommended that the inoculation of the flock be completed in April or May before the advent of the first rains in order that the sheep may enjoy the greatest measure of protection during the period of greatest risk. The resultant immunity steadily wanes with the passage of time and in order to maintain it at a satisfactory level it is necessary that the inoculation be repeated annually. The dose of alum precipitated entero-toxaemia vaccine for both sheep and lambs is 5 c.c.s. Unless there is reason to fear heavy mortality from the disease a single injection will suffice to protect the flock for the duration of the season. If, however, there is reason to anticipate a heavy death rate a further injection of 5 c.c.s. should be given after a period of four weeks has elapsed. This second injection will greatly increase the degree of immunity which should now be capable of preventing losses from the disease under almost any conditions. In any circumstances, however, double inoculation is the safest procedure that can be adopted.

Lambs should for preference be inoculated at the time of marking and if they are not intended for export may, as in the case of grown sheep, be inoculated beneath the skin of the thigh or brisket. The vaccine produces no ill effects upon

the animal. A firm nodule, however, develops at the site of the injection and several months may elapse before this is absorbed and finally disappears.

The abovementioned treatment is relatively inexpensive, the vaccine costing little more than a halfpenny per dose. A leaflet describing the method of inoculation is available upon application to this Department.

IMMUNISATION OF THE LAMB BY INOCULATION OF THE PREGNANT EWE.

In those countries where heavy losses from infectious entero-toxaemia ("pulpy kidney" disease) occur in lambs less than one month old immunisation presents a more difficult problem. The early age at which death occurs precludes inoculation of the lamb itself. It is consequently necessary to endeavour to immunise the young animal through its mother. The procedure generally adopted consists in inoculating the ewe with 5 c.es. of alum precipitated vaccine at the time of mating followed by a further dose of 10 c.es. ten to fourteen days before lambing by which time the immunity will have reached its highest level. The immunity thus conferred upon the ewe is transmitted to the lamb through the colostrum or first milk sucked. It is of the passive type persisting for three or four weeks and then rapidly declining. It may, however, be sufficient to tide the lamb over this critical period and has been shown to be capable of considerably reducing the mortality rate. Observations have shown that in Western Australia lambs do not usually become affected by the disease until reaching the age of eight or ten weeks. Consequently the abovementioned procedure does not appear to be warranted in this State.

INOCULATION OF THE EXPORT LAMB.

When alum precipitated entero-toxaemia vaccine is employed the inoculation of lambs intended for export presents a special problem on account of the development of a nodule at the site of injection. Before the carcass can be passed as suitable for export this nodule must be removed. The removal of nodules from the brisket or the inner surface of the thigh causes the underlying muscle to become exposed thus blemishing the carcass. A blemish of this nature may cause the carcass to be placed in a lower grade or to be rejected altogether for export purposes in which case it will pass into local consumption at a reduced figure. This will constitute a source of loss both to the grower and the State. It is consequently recommended that export lambs be inoculated on some portion of the body where the appearance of a nodule will not blemish the dressed carcass. A suitable site will be found on the inside of the knee where the skin is sufficiently loose to enable the injection to be made. Experience in this State has shown that lambs may be very satisfactorily inoculated beneath the skin in close proximity to the base of the ear. Inoculation should be combined with marking, the injection being made while the lamb is being held on the marking rail. The head of the animal should be inclined slightly away from the operator, the ear pressed down on the head and a small amount of wool removed with shears over the site of inoculation. In making the injection the needle should be inserted in the direction of the top line of the neck. Co-operation between catcher, marker and inoculator will enable both operations to proceed without loss of time. The nodule if still present when the animal is slaughtered will either be removed with the head or it may be trimmed from the extremity of the neck.

As an alternative method export lambs may be inoculated in the thigh or brisket with "old type" entero-toxaemia vaccine (containing no alum) which does not produce a nodule but they will not enjoy the same high degree of protection

as in the case of animals treated with the alum precipitated product. To bring this about a second injection—the dose in each instance being 5 c.es.—would need to be given after an interval of four weeks. By using this method, however, the lamb would not be adequately protected against the disease for so long a period.

MEASURES NECESSARY TO CONTROL AN OUTBREAK OF INFECTIOUS ENTERO-TOXAEMIA.

In the event of an outbreak of the disease occurring amongst uninoculated sheep inoculation with entero-toxaemia vaccine (alum precipitated) should be practised immediately. An interval of 10-14 days will elapse before an immunity sufficiently strong to prevent further losses will be established and in the meantime the expedient of turning the sheep on to scrub country or of shifting them from one paddock to another at frequent intervals should be adopted. Should a single injection fail to completely check the mortality a second injection which will considerably increase the degree of immunity should be given after an interval of 3-4 weeks.

Mortalities may occasionally be experienced in flocks which have been inoculated a few months previously and in such cases it would appear that in the meantime the immunity has waned to such an extent that it is no longer capable of preventing the disease, particularly if the animals are exposed to unusually heavy infection. When this occurs a dose of 5 c.es. of alum precipitated vaccine should be injected immediately and it should succeed in preventing further losses within the space of a few days. In the case of an animal previously sensitised by inoculation the second injection of vaccine will provoke an immediate response, the immunity commencing to rise sharply almost from the moment of its administration.

SUMMARY.

Infectious entero-toxaemia occurs over a wide area of the agricultural districts and on account of the losses for which it is responsible it must be considered the most serious of the diseases affecting sheep in this State.

The disease is largely confined to the winter and spring months when green feed is available; the losses ceasing when the feed dries off.

Mortalities do, however, occur during the dry season chief amongst these being those which are associated with the consumption of flowering stinkwort during late summer and autumn.

Losses may also occur in the case of sheep subsisting to a large extent on concentrated rations such as dried peas, fallen or unharvested wheat and concentrates fed as supplements.

Sheep in fat condition are usually affected but this is not invariably the case.

Death occurs suddenly usually being preceded by symptoms of such short duration that more often than not they pass unnoticed. The changes observed at post mortem are slight.

Following death the carcase putrefies at an abnormally rapid rate soon becoming bloated with gas and discoloured.

The decomposition of the kidneys is especially rapid. These organs, while showing little change at the time of death, appear characteristically soft and pulpy when a post mortem examination is carried out three or four hours thereafter.

The disease is caused by *Cl. Welchii* Type D, a micro-organism which occurs commonly in the soil. Normally this organism passes through the intestine of the sheep without producing any ill effects. When, however, a condition of temporary stasis or sluggishness of the bowel develops the organism is enabled to multiply in the small intestine producing a toxin or poison the absorption of which is responsible for the development of the disease.

Fibre is a powerful stimulant to bowel activity consequently a diet low in fibre content, such as luxuriant green feed or concentrates, might be expected to set up a condition of bowel sluggishness thus predisposing to the disease.

Lack of exercise which is generally associated with such feeding conditions appears to be a complicating factor.

The injury inflicted upon the bowel wall by barbed hairs derived from flowering stinkwort also favours the growth of the organism in the small bowel contents.

The diagnosis may be established by the laboratory examination of small bowel contents, facilities for which are provided by this Department.

The disease may be prevented by inoculation with entero-toxaemia vaccine.

Inoculation of the flock during April or May is advised.

The use of alum precipitated entero-toxaemia vaccine is recommended. A single injection of 5 c.c.s. of this vaccine will usually give satisfactory results. A second injection given after an interval of four weeks will greatly increase the degree of immunity and this procedure should be adopted where there is reason to fear a heavy mortality rate and where a greater measure of protection against the disease is desired.

Lambs intended for export should be inoculated on some part of the body, such as the inside of the knee or at the base of the ear where the development of a nodule resulting from the injection will not blemish the dressed carcase.

Outbreaks of the disease may be controlled by the immediate inoculation of the flock with alum precipitated vaccine which may be expected to produce an immunity strong enough to prevent further losses after the lapse of fourteen days. In the meantime an endeavour should be made to check the mortality by shifting the sheep from paddock to paddock frequently or by transferring them to scrub country.

Tubercle-Free Herds.

The following herds have been declared free from tuberculosis in accordance with the requirements of the Scheme for the certifying of herds tubercle-free, and unless otherwise declared the certificate remains in force until the date shown in respect of each herd:—

No.	Owner.	No. of Cattle Tested.	Date of Expiry.
1941.			
1	A. Groves, Toodyay and Wagerup ...	187	31st December.
2	School of Agriculture, Narrogin ..	36	do.
3	Agricultural College, Muresk ...	44	31st October.

Four New Noxious Weeds

TOGETHER WITH NOTES ON THE BURR GRASS WEEDS NATURALISED IN WESTERN AUSTRALIA.

C. A. CARDNER, Government Botanist.

The recent declaration of Innocent Weed in Western Australia as a noxious weed for the State includes four species, three of which are already naturalised here, the other not yet recorded, but prevalent as a serious weed in Victoria and South Australia, and already a declared noxious weed for the latter State.

Burr grass is the name given generally to species of the genus *Cenchrus*, of which there are some twenty-five species of tropical and warm temperate origin in both hemispheres. It must not be imagined however, that all these burr grasses, or at least that all species of *Cenchrus* are weeds, for on the contrary, three which have been introduced into the northern pastoral areas of Western Australia have proved themselves species of inestimable value as pasture grasses in areas too dry for cultivation. Such are the two Buffel grasses, and Birdwood grass, all of which are being encouraged in these parts of Western Australia which lie to the north of the Gascoyne River.

There are seven species of *Cenchrus* in Western Australia, of which number one is native, and the others introduced. The native species *C. elymoides* F. Muell. is known in Western Australia only from Sturt's Creek in East Kimberley. We possess no specimen of this plant in the Perth Herbarium, but from the description it would appear to belong to the group that are valuable pasture grasses. Then there are the three introduced pasture species *C. pennisetiformis* Hochst. & Steud and *C. ciliaris* L., the two Buffel grasses, and *C. setigerus* Vahl., the Birdwood grass. All of these are native to Tropical Africa, and extend to India. It is probable that they hybridise, since they appear to grow in association. In fact, *C. pennisetiformis* may itself be a hybrid. The four species enumerated are essentially plants of arid regions which require warm summer rains for their successful growth, and they cannot be expected to grow under winter rainfall conditions. The introduction of three of them has proved of immense value to the pastoralists of the North, and Birdwood grass alone is hardy enough to thrive under conditions where spinifex dominates the country. The four form a group in which the burrs have fine bristles which are not prickly, and not in any way objectionable to stock.

For the purposes of this article we are not concerned with the above, but with four other sand burrs which are to be regarded as weeds because of their spiny burrs which render them objectionable, and which also enable the seeds to be readily transported from place to place in hair, wool or clothing. The declaration of Innocent weed in South Australia and Western Australia demands that attention should be drawn to four plants, three of which are already established here, and the fourth, one of the most serious, which it is intended shall as far as possible be excluded. These four are illustrated for the information of those concerned, and a key for the identification of the introduced species is given.

1. *C. incertus* M. A. Curtis—Native to North America.—A perennial species often flowering the first year, forming dense clumps of leafy culms, much branched, and diffuse or ascending, and attaining a height of about three feet. The ligule is ciliate, and the leaf-blade which is folded or flat, rather stiff, scabrous and hairy on the upper surface. The burrs are less than a quarter of an inch in diameter, with few broad spines, finely pubescent, with a short tapering base free of spines.



Cenchrus tribuloides L. A, Habit of plant; B, Involucre or "burr"; C, *C. pauciflorus* Benth. "burr."

This species is represented in Western Australia by a specimen from South Bunbury submitted by Mr. H. Moore in February, 1927. The specimens are less than twelve inches high, and very leafy.

2. *C. echinatus* L.—Native to the warmer parts of America, and introduced into Hawaii, the Philippines, Samoa and North-Western Australia.

An annual plant attaining a height of nearly three feet with ascending branched culms and very loose leaf-sheaths. The ligule is ciliate and the leaf-blade commonly up to eight inches long, flat and rather wide, and soft. The body of the burr is about a quarter of an inch broad, with flattened stout spines in the upper portion and numerous slender spines at or near the base.

This species is naturalised around Broome where it is proving troublesome, and spreading. There is also a specimen collected at Denham, Shark Bay, growing in sand near the sea.

3. *C. pauciflorus* Benth.—Native to America, from the Rocky Mountains southwards to Brazil and the Argentine, and also in the West Indies.

An annual plant with spreading culms forming a mat-like mass, or more rarely almost erect, attaining a height of three feet; leaf-sheath loose, pubescent along the margin; ligule ciliate; leaf-blade flat or folded, spreading, $1\frac{1}{2}$ to six inches long, up to $\frac{1}{2}$ -inch broad, scabrous above and sometimes below. Burrs in spikes $\pm$ included in the sheath of the leaf, the body of the burr usually less than a quarter of an inch in diameter, densely pubescent or rarely almost glabrous, with numerous spreading or reflexed spines, the outermost short and slender, the inner rigid and flattened and hairy towards the base, usually about eight in number, rigid and spine-like.

This species is recorded from South Caroling, where it was collected by A. K. Thomson in January, 1924. It apparently represents a tall plant, but the material is poor.

4. *C. tribuloides* L.—America, from New York to Brazil, in loose coastal sands.

An annual plant, very leafy, the culms branched, decumbent or erect, attaining a height of eight inches, rooting at the nodes; leaf-sheath broad and inflated, $\pm$ pubescent; ligule ciliate; leaf-blade flat or folded, firm, spreading, 2-8 inches long, scabrous on the upper surface; spikes shorter than the leaf, and partially included in the sheath, the body of the burr nearly half an inch in diameter, usually conspicuously villous or silky-hairy, and if the indumentum is shorter, with a few long hairs at the base of the burr; spines spreading, the outer short and slender, the inner much flattened towards the base and long hairy on the inner face and margins, terminating in rigid needle-like points.

Not yet recorded for Western Australia, common in South Australia and Victoria—a weed of waste lands and neglected cultivated areas.

CENCHRUS L.

Key to the species occurring in Western Australia.

- A. Bristles or hairs erect, not divaricately spinescent. Tropical forage plants.
 - a. Panicle up to 45 cm. long; involucre with one of the inner bristles elongated into an awn, all beardless .. 1. *C. elymoides* F. Muell.
 - b. Panicle not exceeding 6 cm.; dense and spikelike; inner bristles not markedly unequal, antrorsely barbed.
 - a. Outer bristles slender and hair-like; inner bristles ciliate and ending in fine hair-like points.

- I. Inner bristles connate at the base only 2. *C. ciliaris* L.
- II. Inner bristles connate for 1-3 mm. above the base .. 3. *C. pennisetiformis* *Hochst. et Steud.*
- β . Outer bristles reduced to small deltoid teeth; inner bristles connate almost half their length, much flattened, erect, without long points, $\mp$ glabrous .. 4. *C. setigerus* *Vahl.*
- B. Bristles, at least the inner, much connate, dilated and divaricately spreading, ending in firm spinescent points retrorsely barbed or glabrous. Weeds.
 - a. Involucre with a ring of slender bristles at the base. Annual .. 5. *C. echinatus* L.
 - b. Involucre without a basal ring of slender bristles or spines.
 - α . Involucre (excluding the spines) less than 3.5 mm. diameter, with a slender tapering base; spines few. Perennial 6. *C. incertus* *M. A. Curtis.*
 - β . Involucre (excluding the spines) 5 mm. or more in diameter, without a tapering base, globose or ovoid in outline; spines numerous; annuals.
 - I. Involucre (including spines) 7-8 mm. diameter, finely pubescent 7. *C. pauciflorus* *Benth.*
 - II. Involucre (including the spines) 1-2 mm. diameter, densely villous 8. *C. tribuloides* L.

The plants of most concern to the agriculturist are the two species *C. pauciflorus* and *C. tribuloides*, both of which are of the same economic importance. Both are annual plants which may appear in waste places or neglected cultivations. Wherever they occur they can be controlled by hand-pulling before the burrs mature. Plants in which the burrs have already formed should be pulled and destroyed by burning. This treatment should, where practicable, be followed by ploughing in the following winter and the establishment of a clean crop. The weed is of particular importance in orchards, because they are summer growing annuals which may be expected to find a suitable home in soils moist in summer.

The name *Cenchrus* is taken from *Kenkhros*, the Greek name for Millet.

The accompanying figures will serve to help in the identification of these plants. Any plant suspected of being one of the undesirable species should be collected, pressed, and forwarded to the Government Botanist, Perth.



Cenchrus echinatus L. A, portion of culm with inflorescences; B, involucre; C, involucre of *C. incertus*. "burr."

ACKNOWLEDGMENT.

Acknowledgment is made to Contributions from the United States National Herbarium xxii., p. 1, "North American Grasses," by Hitchcock and Chase, from which the drawings of the burrs were copied.

Field Experiments with Wheat and Oats, 1940, at the Agricultural Research Stations.

I. THOMAS,

Superintendent of Wheat Farming.

At each of the Research Station located in the Wheat Belt, field experiments with wheat and oats are conducted each year. These Research Stations are widely separated and embrace a considerable variation of soil and climatic conditions.

The field experiments conducted cover a wide range and include such important phases as fallowing, and frequency of cultivation. The most prolific varieties, the best time to plant, the most economical rates of seed and superphosphate to apply, the effect of various fungicides upon the yields are ascertained and fodder and other trials carried out.

With but one or two minor exceptions experimental plots are one-eighth of an acre in area. They are long and narrow, being one drill width wide, and measure 833 links by 15 links, and are replicated five times.

They are designed on the "three plot" system, the centre plot of each section (three plots) being the control—thus each varying factor is adjacent to a control plot.

For convenience of comparison of similar experiments the results of these from one or more of the Research Stations have been grouped and discussed together.

Unfortunately owing to a severe drought it was not possible to obtain any results from the experiments conducted at the Merredin Research Station during 1940, and those at Salmon Gums were also affected to some extent by the unfavourable conditions in addition to a severe hailstorm prior to harvesting.

With the exception of certain specific experiments the whole are planted on portion of the area on which the bulk crops are sown. The cultural operations prior to seeding are, with the exception of those requiring special treatments, similar to those for the bulk crops, also with the exception of those experiments with defined treatments the rates of seed and superphosphate are those adopted at the respective stations. The land is ploughed during the preceding winter months, cultivated in the spring and prior to seeding, either with a spring-tyne or rigid-tyne cultivator, depending upon circumstances; additional cultivations are only given when warranted by special circumstances such as excessive weed growth. A disc drill is used for the seeding of all experiments.

In any discussion of the field experiments due regard must be taken of the soil, seasonal conditions, etc., experienced at the respective stations and the following few notes will be of assistance in this direction.

CHAPMAN RESEARCH STATION.

Situated on the Upper Chapman River 28 miles north of Geraldton and 334 miles by rail from Perth. The land is mostly typical loamy jam and wattle country with slight intrusions of heavier York gum. This is the oldest established station and the land has been under cultivation for many years.

RAINFALL.

Year.	Jan.	Feb.	Mar.	Apr.	Growing Period.							Nov.	Dec.	Total for Year.
					May.	June.	July.	Aug.	Sept.	Oct.	Total.			
1940	27	...	12	1	175	268	401	92	113	83	1,132	14	51	1,237
Av., 34 years	28	41	73	67	235	423	388	279	151	92	1,571	37	26	1,844

Though the rainfall was one of the lowest on record the late seasonal rains in September and October were very beneficial with the result that, despite an anxious early period, crops finished well. The late commencement of the season, however, necessitated the planting of some of the experiments somewhat later than usual. On this station weed growth is also likely to be troublesome if seeding is commenced too early without efficient weed control.

Harvest results were:—

Wheat	..	..	..	108 acres (a	17 bus.	52 lb per acre.
Oats	..	..	..	103	..	15 ..
Barley	..	..	..	9	..	14 ..
Hay	..	..	..	81	..	25 cwt.

WONGAN HILLS RESEARCH STATION.

This station, which is probably unique in Australia, is situated on typical sandplain country and the results obtained are an indication of what can be achieved on this type of soil of which there are large areas in the Western Australian Wheat Belt. The original vegetation was, in the main, smoke bush, (*Conospermum spp.*), wattle (*Acacia spp.*) and other low scrub.

RAINFALL.

Year.	Jan.	Feb.	Mar.	Apr.	Growing Period.							Nov.	Dec.	Total for Year.
					May.	June.	July.	Aug.	Sept.	Oct.	Total.			
1940	59	6	5	2	90	202	237	29	77	95	730	5	98	905
Av., 14 years	34	55	90	91	180	246	267	208	88	80	1,069	51	29	1,419

With a late opening, after a long dry summer and autumn, prospects were not promising, but with good June and early July rains followed by excellent late finishing rains, the yield of the wheat crops was very satisfactory, the oats suffering from storm damage however.

Harvest results were:—

Wheat	..	..	..	277 acres at	17 bus.	20 lb. per acre
Oats	..	..	..	193	..	12 ..
Hay {	Wheat	..	..	35	..	14 cwt.
	Oats	..	..	71	..	11 ..

SALMON GUMS RESEARCH STATION.

This station is situated in the Esperance Wheat Belt and embraces a variety of soil types from heavy to lighter types and includes such unsatisfactory types as "Kopi" and Kumarl clay loam. The original vegetation ranged from heavy and light mallee to tea-tree and scrub. Embracing as it does several unsatisfactory soil types a number of specific experiments are carried out on such land.

RAINFALL.

Year.	Jan.	Feb.	Mar.	Apr.	Growing Period.							Nov.	Dec.	Total for Year.
					May.	June.	July.	Aug.	Sept.	Oct.	Total.			
1940	50	...	19	7	158	69	82	48	67	98	522	89	145	832
Av., 14 years	118	68	132	93	131	147	152	169	86	114	801	104	58	1,376

The past season was most unsatisfactory, both autumn and spring rains being of little benefit. Yields therefore were very low and were:—

Wheat	..	..	..	43 acres @	6 bus.	50 lb	per acre
Oats	..	..	..	110 "	" "	3 "	37 " " "
Hay	..	..	..	118 "	" "	3¾ cwt.	" "

The yields for the wheat crop were affected by a hailstorm prior to harvesting by approximately 1½ bushels per acre and the oats by a severe windstorm which more than halved the yield.

AVONDALE RESEARCH STATION.

Situated in an old-established district on the western fringe of the Wheat Belt, four miles from Beverley, on the Great Southern Railway. The land is undulating loamy jam, wattle and York gum country, which lends itself to mixed farming, with the emphasis on livestock rather than wheat growing.

RAINFALL.

RAINFALL.														Total for Year.
Year.	Jan.	Feb.	Mar.	Apr.	Growing Period.						Nov.	Dec.		
					May.	June.	July.	Aug.	Sept.	Oct.			Total.	
1940	110	....	....	41	69	232	159	87	147	53	747	8	86	992
Av., 13 years	24	51	124	82	251	295	325	253	101	104	1,329	45	27	1,682

Though the early period of the season was difficult later rains were beneficial and, with good finishing rains, satisfactory yields were obtained.

Harvest results were:—

Wheat	..	..	..	91½ acres	19 bus.	17 lb.	per acre
Oats	..	..	..	95 "	16 "	15 "	" " "
Barley	..	..	..	57 "	15 "	14 "	" " "
Hay	..	..	..	72 "	30 cwt.		

Details of the grouped experiments are as follows:—

Fallow v. Non-Fallow Experiment.

The object of this experiment is to determine the effect of fallowing land on the subsequent yield of the wheat crop.

CHAPMAN RESEARCH STATION.

Variety—Nabawa.

Superphosphate—112 lb. per acre. Seed—60 lb. per acre.
Planted on 10th June, 1940.
Germinated on 19th June, 1940.

WONGAN HILLS RESEARCH STATION.

Variety—Totadgin.

Superphosphate—120 lb. per acre.
Seed—45 lb. per acre.
Planted on 5th June, 1940.
Germinated on 16th June, 1940.

Treatment.	Average Yields per acre, 1940.	Percentage Yields, 1940.	Average Yields per acre, 1929-40.	Percentage Yields, 1929-40.	Average Yields per acre, 1940.	Percentage Yields, 1940.
Fallow	bus. lb. 27 24	152	bus. lb. 18 0	135	bus. lb. 16 45	129
Non-Fallow	17 57	100	13 20	100	12 58	100

The results this year and the average results over a period of 12 years emphasise the advantage of sowing the wheat crop on fallowed land.

Those for Wongan Hills though for one year only are similar to those from Chapman. These results are also borne out by statistical data for Western Australia which indicates that the average increased yield from fallowed land is in the nature of approximately four bushels per acre.

1. *Rate of Seeding Experiment.*

The object of this experiment is to determine the most economical rate at which to seed:—

(a) a midseason free-stooling variety, and

(b) an early sparse-stooling variety.

Free-Stooling Variety.

CHAPMAN RESEARCH STATION.

Variety—Nabawa.

Superphosphate—112 lb. per acre.

Planted on 12th June, 1940.

Germinated on 19th June, 1940.

WONGAN HILLS RESEARCH STATION.

Variety—Nabawa.

Superphosphate—125 lb. per acre.

Planted on 30th May, 1940.

Germinated on 10th June, 1940.

Rate of Seed per acre.	Average Yields per acre, 1940.	Per- centage Yields, 1940.	Average Yields per acre, 1923-40.*	Per- centage Yields, 1923-40.*	Average Yields per acre, 1940.	Per- centage Yields, 1940.	Average Yields per acre,	Per- centage Yields, 1925-40.*
60 lb.	bus. lb. 21 2	108	bus. lb. 15 51	104	bus. lb. 22 50	107	bus. lb. 17 54	103
45 lb.	19 25	100	15 18	100	21 14	100	17 23	100
90 lb.	24 27	126	17 1	111	23 2	108	17 58	103

* Excluding 1929 and 1932.

* Excluding 1937.

Sparse-Stooling Variety.

CHAPMAN RESEARCH STATION.

Variety—S.H.J.

Superphosphate—112 lb. per acre.

Planted on 12th June, 1940. Germinated on 19th June, 1940.

WONGAN HILLS RESEARCH STATION.

Variety—Merredin.

Superphosphate—125 lb. per acre.

Planted on 30th May, 1940.

Germinated on 10th June, 1940.

Rate of Seed per acre.	Average Yields per acre, 1940.	Per- centage Yields, 1940.	Average Yields per acre, 1923-40.*	Per- centage Yields, 1923-40.*	Average Yields per acre, 1940.	Per- centage Yields, 1940.	Average Yields per acre,	Per- centage Yields, 1925-40.*
60 lb.	bus. lb. 23 2	101	bus. lb. 17 6	106	bus. lb. 16 37	110	bus. lb. 14 30	103
45 lb.	22 45	100	16 10	100	14 59	100	14 1	100
90 lb.	24 37	108	17 58	111	16 14	108	14 43	105

* Excluding 1932.

* Excluding 1937.

Though this year's results indicate that the rate of seeding could be profitably increased from 45 to 60 lbs. per acre the average figures over a period of 15 years do not sustain this result. At Chapman a rate of 60 lbs. per acre is to be preferred on account of possible weed trouble.

2.

Time of Seeding Experiment.

This experiment is being conducted to determine the most suitable month for planting the wheat crop.

(a) a midseason free-stooling variety, and

(b) an early sparse-stooling variety.

Free-Stooling Variety.

WONGAN HILLS RESEARCH STATION.

Variety—Nabawa.

Superphosphate—125 lb. per acre. Seed—45 lb. per acre.

SALMON GUMS RESEARCH STATION.

Variety—Bencubbin.

Superphosphate—112 lb. per acre.
Seed—45 lb. per acre.

Planted.	Average Yields per acre, 1940.	Per-centage Yields, 1940.	Average Yields per acre, 1929-40.	Per-centage Yields, 1929-40.	Average Yields per acre, 1940.	Per-centage Yields, 1940.	Average Yields per acre, 1928-40.	Per-centage Yields, 1928-40.
Mid-April	bus. lb. 7 57	71	bus. lb. 16 20	98	bus. lb. 7 52	105	bus. lb. 13 9	94
Mid-May	11 9	100	16 37	100	7 29	100	13 53	100
Mid-June	23 33	211	13 19	80	1 35	21	9 25	67

Sparse-Stooling Variety.

WONGAN HILLS RESEARCH STATION.

Variety—Gluyas Early.

Superphosphate—125 lb. per acre. Seed—45 lb. per acre.

SALMON GUMS RESEARCH STATION.

Variety—Gluyas Early.

Superphosphate—112 lb. per acre.
Seed—45 lb. per acre.

Planted.	Average Yields per acre, 1940.	Per-centage Yields, 1940.	Average Yields per acre, 1928-40.	Per-centage Yields, 1928-40.	Average Yields per acre, 1940.	Per-centage Yields, 1940.	Average Yields per acre, 1928-40.	Per-centage Yields, 1928-40.
Mid-June	bus. lb. 23 20	180	bus. lb. 14 14	86	bus. lb. 2 9	32	bus. lb. 11 45	78
Mid-May	12 58	100	16 30	100	6 34	100	14 55	100
Mid-July	30 32	158	10 33	63	1 4	16	8 43	58

Owing to the unusual distribution of the rainfall throughout the 1940 season, both midseason and early varieties at Wongan Hills yielded best when planted in June. Taken on average figures over the period 1929-1940 best results are obtained from planting of the wheat crop during May. At Salmon Gums where seasonal conditions differ somewhat, the April sowing during 1940 was more satisfactory but it can be generally recommended that the wheat crop should be sown in May and that early seeding in the right order of maturity is preferable to late sowing.

Rate of Application of Superphosphate Experiment.

The object of this experiment is to determine the most economical amount of superphosphate to apply to the wheat crop.

SALMON GUMS RESEARCH STATION.

Variety—Gluyas Early.

Seed—45 lb. per acre.

Planted on 5th June, 1940. Germinated on 25th June, 1940.

CHAPMAN RESEARCH STATION.

Variety—Nabawa.

Seed—60 lb. per acre.

Planted on 11th June, 1940.
Germinated on 19th June, 1940.

Rate of Application of Superphosphate per acre.	Average Yields per acre, 1940.	Percentage Yields, 1940.	Average Yields per acre, 1929-40.	Percentage Yields, 1929-40.	Average Yields per acre, 1940.	Percentage Yields, 1940.	Average Yields per acre, 1929-40.	Percentage Yields, 1929-40.
<i>Nil</i>	bus. lb.		bus. lb.		bus. lb.		bus. lb.	
150 lb.	2 1	62	6 50	46	15 38	78	11 50	81
75 lb.	3 15	100	14 50	100	20 6	100	14 34	100
	2 49	86	13 6	88	19 46	98	13 54	95
225 lb.	5 22	108	17 14	105	22 0	100	14 55	103
150 lb.	4 58	100	16 24	100	21 55	100	14 30	100
300 lb.	5 46	116	17 14	105	22 6	101	14 36	101

WONGAN HILLS RESEARCH STATION.

Variety—Nabawa.

Seed—45 lb. per acre.

Planted on 24th May, 1940.

Germinated on 3rd June, 1940.

Rate of Application of Superphosphate per acre.	Average Yields, per acre, 1940.	Percentage Yields, 1940.	Average Yields per acre, 1929-40*	Percentage Yields, 1929-40.*
<i>Nil</i>	bus. lb.		bus. lb.	
150 lb.	3 47	15	3 9	16
75 lb.	24 53	100	19 49	100
	20 51	84	15 49	80
225 lb.	19 23	97	20 55	103
150 lb.	19 55	100	20 18	100
300 lb.	20 0	100	21 6	104

* 1937 excluded.

These trials are conducted in two sections, heavy and light dressings, and cover a sufficiently wide range for the purpose of the experiment.

The results indicate that an increase above 75 lbs. per acre is economic but the actual amount varies at the different stations and hence in different districts in the Wheat Belt.

On the light soil at Wongan Hills increases up to 150 lb. per acre are payable. It is recommended that on light soils the minimum dressing be 120 lbs. per acre. On the better class of soils at least 75 lbs. should be applied and though the yield is increased somewhat when the rate is raised to 150 lbs. per acre an application of at least 100 lbs. per acre could be used to advantage. At both Chapman and Merredin Stations the land has been under cultivation for many years, and it is practically certain that even the plots that now receive no dressing of superphosphate benefit from the residual effect of the previous dressings. Little definite information is available about the residual effect of superphosphate in Western Australian soils though it is known that the actual phosphate content, particularly the available phosphate, is low. In this connection the following notes are of interest.

Residual Effect of Superphosphate.

Allied to the question of the optimum annual rate of dressing with superphosphate is that of the residual value of this manure in the soil from previous dressings. That it has a considerable residual value is apparent at the Wongan

Hills Research Station where plots which, when first cleared, would grow no crop without super, now make some growth due to the effect of the previous dressing of super.

On the other hand, two points tending to depress the residual value of the manure, should be noted. Firstly, it has been estimated that a 20-bushel crop removes from the soil the equivalent of about 60 lbs. of 23 per cent. superphosphate and this must be replaced to prevent soil depletion. Secondly, soluble phosphates react with the soil and are changed into insoluble forms. This was shown by experiments conducted at the Merredin, Wongan Hills and Chapman Research Stations some years ago. Water-soluble phosphate was mixed with moist soil and determination of the amount remaining in the water-soluble form was made four months later. The amounts were very small.

When the above facts are considered in the light of the knowledge that most seedlings demand readily available supplies of water-soluble superphosphate for optimum development, it will be realised that it is inadvisable to curtail severely the rate of superphosphate dressing, even following a drought year when the actual amount removed by the growing plants had been low. To obtain precise information about this residual effect under West Australian soil conditions, experiments are being initiated this year at the Wongan Hills and Merredin Research Stations.

Fungicide Experiment (Wheat and Oats).

The object of this experiment is to determine the comparative effect of copper and organic mercuric fungicidal dusts upon the germination, growth and grain yields of wheat and oat crops.

CHAPMAN RESEARCH STATION.

Variety—Nabawa.

Superphosphate—112 lb. per acre. Seed—60 lb. per acre.

Planted on 17th June, 1940. Germinated on 21st June, 1940.

WONGAN HILLS RESEARCH STATION.

Variety—Totadgin.

Superphosphate—125 lb. per acre.

Seed—45 lb. per acre.

Planted on 6th June, 1940.

Germinated on 16th June, 1940.

Seed Treatment.	Average Yields per acre, 1940.	Per-centage Yields, 1940.	Per-centage Yields, 1938-40.	Average Yields per acre, 1940.	Per-centage Yields, 1940.	Per-centage Yields, 1938-40.
	bus. lb. 25 23	98	102	bus. lb. 9 38	101	100
Mercury Compound A						
Copper Carbonate	26 2	100	100	9 31	100	100
Mercury Compound B	24 54	96	106	9 49	103	101

WONGAN HILLS RESEARCH STATION.

Planted on 6th June, 1940.

Variety—Mulga.

Germinated on 17th June, 1940.

Superphosphate—135 lb. per acre.

Seed—40 lb. per acre.

Treatment.	Average Yields per acre, 1940.	Percentage Yields, 1940.	Average Yields per acre, 1938-40.	Percentage Yields, 1938-40.
	bus. lb. 9 36	105	bus. lb. 15 24	97
Mercury Compound A				
Copper Carbonate	9 16	100	16 4	100
Mercury Compound B	9 20	101	16 28	104

The results obtained in this experiment have failed to show any superiority in any of the treatments. Germination and growth were uniform throughout, and there was no significant difference in grain yields.

Wheat Variety Trial.

Each year trials are conducted at the several Research Stations, with various standard, introduced and promising crossbred varieties, to determine their suitability to the different wheat growing districts.

At Merredin and Wongan Hills with widely differing soil and climatic conditions, in addition to the main trials planted in mid-May as at the other stations, supplementary plantings of the late varieties are made in mid-April and early varieties in mid-June to obtain further information. Whilst an endeavour is made to have the trials as uniform as possible at all stations the sowing of varieties in districts to which they have proved definitely unsuited are not included. As mentioned earlier, drought conditions prevented results being obtained from Merredin during 1940, whilst those from Salmon Gums have been excluded, since the yields were affected by hail damage.

The accompanying table gives the results of the Wheat Variety Trial planted on three of the Research Stations during 1940.

Two of these, Avondale and Chapman, are situated in the areas of mixed farming with the emphasis on livestock rather than wheat for grain, whilst at the Wongan Hills Research Station the soil is typical of the large areas of light land used so extensively in Western Australia for wheat growing.

In the first column of the table is given the average yield of five plots, each one-eighth of an acre, whilst the next column is the average yield, again in bushels per acre, of their five Nabawa control plots. The yield of each variety is given also as a percentage of the control plot. The average yield over a stated period is given as a percentage of the control (Nabawa).

Although at the Wongan Hills and Merredin Research Stations, the variety trials are sown in mid-April, mid-May and mid-June, irrespective of seasonal conditions, the April and May plantings frequently germinate together or within a few days of one another. This accounts for the similarity in the results at Wongan Hills of these two plantings. It will be noted also that for the abnormal 1940 season, the June plantings gave much better yields than did the earlier sown ones, but experience from previous years and the Time of Planting Experiments show that May sowing definitely gives the best results.

The results confirm the choice of Bencubbin for extensive sowing over most of the State and it is undoubtedly the outstanding mid-season variety.

The very early maturing variety Bungulla has yielded well at Chapman. At the Wongan Hills Research Station it has proved much more prolific than Noongaar and also to be of greater flour strength. The tendency of Bungulla to straw weakness on light land can be counteracted to some extent by late planting.

Produced by Dr. Waterhouse of the Sydney University, the variety Fedweb, although primarily introduced for its reputed rust resistance, is proving to be slightly more prolific than Nabawa. Fedweb is a late-midseason maturing, short strawed variety.

These trials offer a convenient method for testing crossbred against standard varieties and of the four tested, M47, an early maturing, stout strawed variety and W4, a late maturing variety, have yielded satisfactorily. They will be included in further trials.

SEASONAL VARIETY TRIALS CONDUCTED ON RESEARCH STATIONS DURING 1940.

Variety.	Planting Month.	Wongan Hills Research Station.					Avondale Research Station.					Chapman Research Station.*				
		1940-41 Season.			Average over a Period.		1940-41 Season.			Average over a Period.		1940-41 Season.			Average over a Period.	
		Yield per acre.	Yield per acre Adjacent (Nabawa).	Per-centage of the Control.	No. of Years.	Per-centage of the Control.	Yield per acre.	Yield per acre Adjacent (Nabawa).	Per-centage of the Control.	No. of Years.	Per-centage of the Control.	Yield per acre.	Yield per acre Adjacent (Nabawa).	Per-centage of the Control.	No. of Years.	Per-centage of the Control.
Bencubbin	April	bus. lb. 11 58	bus. lb. 10 30	% 114	10	% 112	bus. lb. 21 34	bus. lb. 18 2	% 119	2	% 112	bus. lb. 23 15	bus. lb. 18 51	% 123	4	% 118
	May	10 6	8 0	126	10	112										
	June	20 38	18 48	109	10	105										
Bungulla	May	19 13	8 29	144	2	107										
	June	12 18	17 54	107	2	90										
	May	8 18	7 31	110	11	100										
Carrabin	May						21 20	18 2	118	2	124	20 38	19 30	106	3	105
Dundee	May	6 42	7 20	91	2	98	19 33	18 51	103	2	100	19 14	18 51	102	4	99
Fedweb	May						18 0	19 12	93	2	106					
Ford	May	8 16	8 29	97	10	95										
Ghyas Early	May	10 50	7 17	148												
Gular	May	16 38	18 5	92												
Merredin	June	7 39	7 31	101	10	91	20 22	18 38	109			19 15	18 32	104	2	98
M. 46 (Waratah Nabawa)	June	17 58	18 5	99	10	91										
	April	11 57	10 30	113												
	May	8 11	8 6	102	3	107	18 22	19 12	95	2	102	18 50	18 56	100	4	105
	June	18 29	18 48	103	2	103										
M. 47 (Nizam × Nabawa)	May	6 50	6 35	103	3	107	18 40	18 38	100	2	109	19 4	18 56	100	3	114
	June	19 50	17 54	110	3	109										
M. 51 (Nabawa × Noon-gaar)	June	11 30	18 21	62												
Nabawa	Control	Control	Control	100		100	Control	Control	100		100	Control	Control	100		100
Noongaar	June	12 42	18 21	69	12	88										
Pusa IV	May	7 7	7 17	97												
Sutton	April	10 35	11 34	91	9	108										
	May	6 26	7 20	87	7	97										
W. 4 (Wilfred × Sutton)	April	10 32	11 34	91	2	113										
	May	8 2	6 35	121	3	109	20 45	18 51	110	2	118	20 6	19 30	103	4	106

* Planting of these trials ranged over the four years from late May to early June, though dependent on seasonal conditions endeavour is made to plant in May if at all possible.

In addition to the above certain experiments were conducted at one station only as follows:—

WONGAN HILLS.

Potash Nitrogen Experiment.

The object of this experiment is to determine the effect upon the wheat crop of an application of—

(a) a nitrogenous fertiliser.

(b) a nitrogenous plus a potassic fertiliser, in addition to the usual dressing of superphosphate.

Planted on 24th May, 1940.

Variety—Nabawa.
Seed—45 lb. per acre.

Germinated on 3rd June, 1940.

Rate of Fertiliser per acre.	Average Yields per acre, 1940.	Percentage Yields, 1940.	Average Yields per acre, 1932-40.*	Percentage Yields, 1932-40.*
25 lb. Super., 112 lb. Sulphate of Ammonia	bus. lb. 27 9	101	bus. lb. 23 14	115
125 lb. Super.	26 45	100	20 10	100
125 lb. Super., 112 lb. Sulphate of Ammonia, 56 lb. Sulphate of Potash	26 43	100	23 14	115

* Excluding 1937.

The results this year show no significant increase in yield due to use of a nitrogenous or a nitrogenous and potassic fertiliser. Taken over the period 1932-40 nitrogenous fertiliser at the rate of 1 cwt. per acre in addition to the usual dressing of superphosphate on the light lands of this Research Station gave an increase in yield of about three bushels per acre. At the present prices of wheat and sulphate of ammonia this would be uneconomic. The addition of sulphate of potash does not give an increased yield. It is suggested, however, that a more economical way of applying nitrogen to the soil would be to incorporate the growing of leguminous fodder plants, such as lupins, clovers, medics, etc., in the farm rotation. This in addition to increasing the amount of available nitrogen in the soil, would also enable increased numbers of stock to be carried.

Oat Variety Trial.

The object of this experiment is to determine the most prolific oat variety for this and similar districts when sown for grain.

Planted on 30th May, 1940.
Germinated on 10th June, 1940.

Superphosphate—125 lb. per acre.
Seed—40 lb. per acre.

Variety.	Average Yields per Acre.	Percentage Yields.	Percentage Yields.
Wongan	bus. lb. 18 38	117	*114
Burt's Early	16 3	100	100
W 2	15 28	97	
W 3	26 2	136	†123
Burt's Early	19 4	100	100
Guyra	26 12	137	†107
Algerian	28 20	157	†116
Burt's Early	18 4	100	100
Algeribee	15 28	86	
Parker's	6 12	35	
Burt's Early	17 32	100	100
Mulga	12 16	69	‡93

* Five years.

† Three years.

‡ Eleven years.

This year Algerian, Guyra and Wongan have shown to advantage, also the Burts Early X Mulga crossbred, W 3. Over a period of years the same varieties have yielded well.

SALMON GUMS.

Experiments on Kopi Soils.

Owing to the unsatisfactory crops of wheat generally obtained from the so-called "Kopi" soils in the Salmon Gums area, experiments have been conducted with a view to obtaining definite information regarding crop response on this class of soil. The original vegetation included giant mallee, a variety of *Eucalyptus oleosa*, and a number of the red morrel family.

The Salmon Gums "Kopi" is described as a light grey, highly calcareous soil. It is fairly powdery, and represents the grey morrel soil of the Eastern Wheat Belt. With working it tends to become a little more compact.

Manurial Experiment.

The object of the experiment is to ascertain whether increased yields which stable manure on these soils gives, when applied in addition to superphosphate, is due to the ash portion or arises from the stable manure as a whole.

Variety—Guyas Early.

Planted on 3rd June, 1940.
Germinated on 22nd June, 1940

Superphosphate—Various rates per acre.
Seed—45 lb. per acre.

Treatment.	Average Yields per Acre, 1940.		Percentage Yields 1940.	
	bus.	lb.	bus.	lb.
112 lb. superphosphate + 15 tons stable manure	3	15	527	
112 lb. superphosphate	0	37	100	
112 lb. superphosphate + stable manure ash equivalent to 15 tons stable manure per acre	0	37	100	

The results which are for one year only show a distinct advantage in favour of stable manure as a whole.

Fodder Experiment.

The object of this experiment is to ascertain the relative yields of green fodder from the common fodder plants when planted on this type of soil, and to determine which of the cereals, wheat, oats and rye, gives the best grain yield.

Yields of Green Fodder.

GREEN FODDER YIELDS (CUT ON 31ST AUGUST).

Planted on 15th May, 1940.

Superphosphate—112 lb. per acre.

Germinated on 30th May, 1940.

Fodder Species.	Average Yields per acre.	Percentage Yields.	Percentage Yields. 1935-40.
	cwt.		
Guyas Early—45 lb.	3.7	112	96
Mulga Oats—40 lb.	5.4	164	122
Mulga Oats + 1 cwt. of Sulphate of Ammonia	5.8	176	122
Rye—45 lb.	4.8	145	145
Wimmera Rye Grass—4 lb.	...	0	42
Wimmera Rye Grass + 1 cwt. of Sulphate of Ammonia	...	0	37

Quadrants from the plots were cut on 31st August to give yields of early green fodder. No cuttings were made from the Wimmera Rye Grass plots owing to the poor growth. No one plot was taken as control and weights yielded by each are expressed as percentage of the mean of all the plots. Rye and Mulga oats both yielded better than the Gluyas Early wheat, and over a period of six years Rye has given the heaviest average yield of early green fodder. An increase in yield on the Mulga oats plots was given in response to the dressing of 1 cwt. of sulphate of ammonia but not sufficient to pay for the extra cost of the manure.

Yields of Grain.

Owing to the dry seasonal conditions that prevailed no grain yields were obtained this year. The average yields for the cereals over the period 1935-40 (inclusive) expressed as lbs. per acre and also as percentages of their mean are given below.

GRAIN YIELDS.

Treatment.	Average Yields per acre, 1935-40.	Percentage Yields, 1935-40.
Gluyas Early	lb. 435	143
Mulga Oats	210	69
Mulga oats + 1 cwt. of sulphate of ammonia	181	60
Rye	387	128

HAY YIELDS.

Planted on 15th May, 1940.

Germinated on 30th May, 1940.

Superphosphate—112 lb. per acre.

Fodder Species.	Average Yields per acre.	Percentage Yields.	Percentage Yields, 1936-40.*
Gluyas Early—45 lb.	cwt. 2.4	109	87
Mulga Oats—40 lb.	2.9	132	99
Mulga Oats—1 cwt. of Sulphate of Ammonia	3.1	141	91
Rye—45 lb.	2.9	132	125
Wimmera Rye Grass—4 lb.	.9	41	100
Wimmera Rye Grass—1 cwt. of Sulphate of Ammonia	1.2	54	95

* 1939 excluded.

Fresh quadrants from the plots were cut on the 16th October to give yields of hay. The yield of each is expressed as a percentage of the mean of all the plots. Rye and Mulga oats gave heavier yields than Gluyas Early wheat or the Wimmera Rye Grass and over a period of four years the rye has given the highest average yield of hay. Sulphate of Ammonia on the oats and Wimmera Rye Grass gave increased yields during 1940, but not sufficient to pay for the extra cost of the manure. The results, however, over the period indicate that there is no economic advantage in this practice.

Fodder Experiments on Clay Soil.

In addition to the experiments on "Kopi" soils, a fodder experiment was conducted on the heavy clay soils which occur in the district.

The object of this experiment is to determine the most suitable crops either as grain or fodder crops on this type of soil.

Yields of Green Fodder.

SALMON GUMS RESEARCH STATION.

GREEN FODDER YIELDS (CUT ON 31ST AUGUST).

Planted on 22nd May, 1940.

Germinated on 5th June, 1940.

Superphosphate—112 lb. per acre.

Fodder Species.	Average Yields per acre.	Percentage Yields.	Percentage Yields (6 years).
Gluyas Early—45 lb.	cwt. 3.8	103	99
Bencubbin—45 lb.	3.4	92	77
Atlas Barley—40 lb.	5.8	157	141
Mulga Oats—40 lb.	4.3	116	80
Rye—45 lb.	4.8	130	130
Wimmera Rye Grass—6 lb. ....	....	....	44

Quadrats were cut from the plots on the 31st August to give the yield of early green fodder. The Wimmera Rye Grass plots were not cut due to the poor growth. Atlas Barley and Rye as in previous years were best yielders.

Hay Yields.

SALMON GUMS RESEARCH STATION.

HAY YIELDS (CUT ON 16TH OCTOBER).

Planted on 28th May, 1940.

Germinated on 5th June, 1940.

Superphosphate—112 lb. per acre.

Fodder Species.	Average Yields per Acre.	Percentage Yields.	Percentage Yields (4 years).
Gluyas Early (45 lb.)	cwt. 2.4	100	95
Bencubbin (45 lb.)	2.2	91	95
Atlas Barley (40 lb.)	3.4	141	120
Mulga Oats (40 lb.)	2.9	121	86
Rye (45 lb.)	2.7	112	123
Wimmera Rye Grass (6 lb.)	1.0	41	82

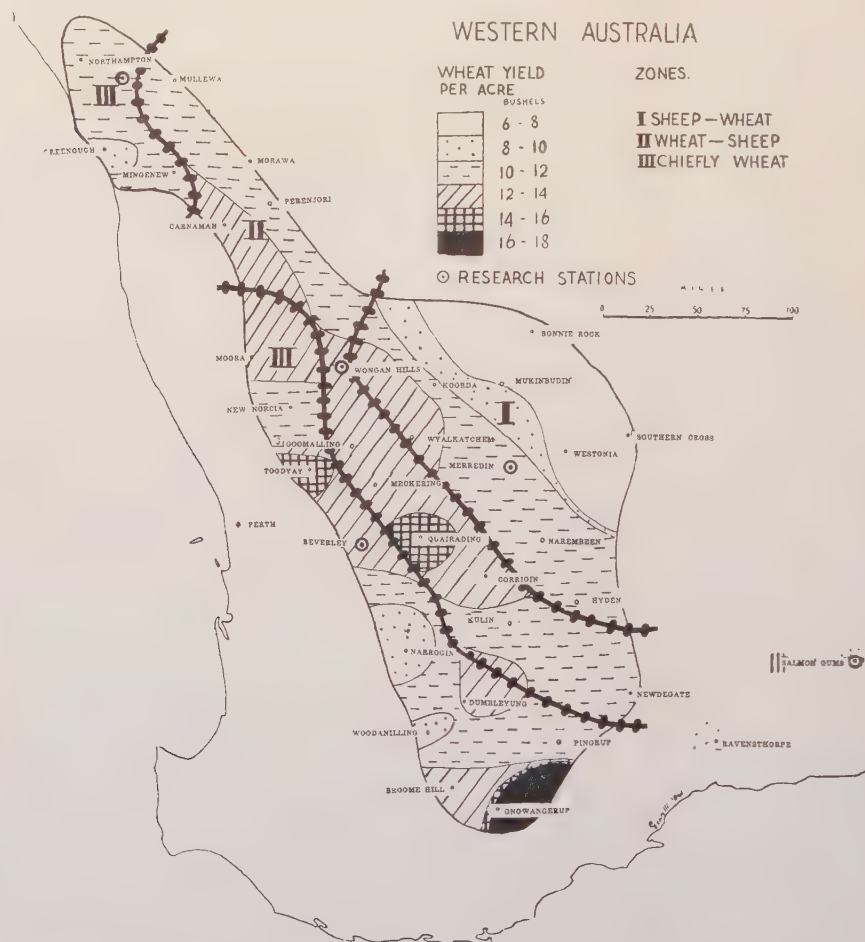
Fresh Quadrats were cut on 16th October and hay yields calculated. Atlas Barley, Mulga Oats, and Rye gave highest yields in that order. Taken over a four-year period, Rye has been the best yielder.

Wheat Yields and Variability in West Australian Districts, 1929-39.

J. GENTILLI, Lecturer in Statistical Methods, University of W.A.

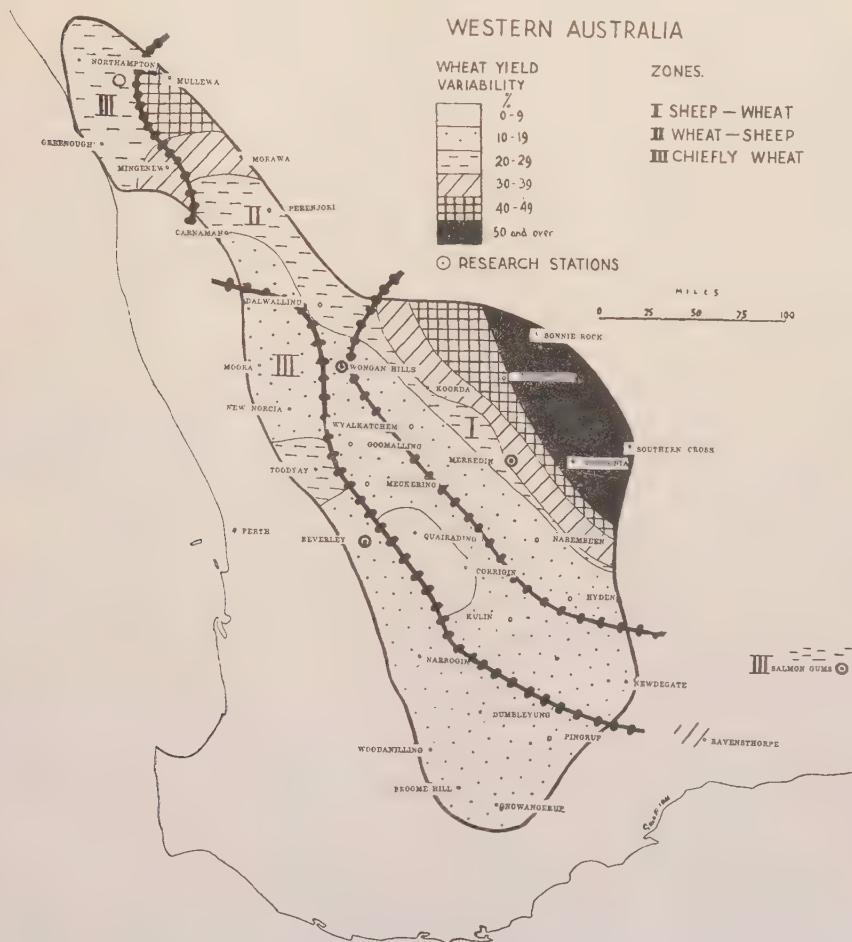
Maps have been prepared by the author with the advice and assistance of officers of the Wheat Branch of the Department of Agriculture to show the average yields and the degree of variability from this average for the wheat growing districts of Western Australia.

The maps are based on data taken from the Statistical Register of Western Australia and cover only the period from 1929-39. Data covering a longer period would have been greatly preferable, but as the statistical boundaries were re-organised at the beginning of this period the figures for previous years would not have been comparable.



In the first map (based on Table 1) the average yield for the districts over the ten-year period is shown. For the second map (based on Table 2) the standard deviation from this mean yield has been calculated for each road board

district as a suitable measure of variability for the district, and then this has been expressed as a percentage of the average yield. This percentage variability represents the amount by which the district yield in any given year is likely to exceed or fall short of its average as determined over the ten-year period.



This concept of variability is important as it will be readily realised that the economic problems could be very different in two districts which had the same average yield over a long period, but of which one had a regular steady yield always close to its average while the other was subject to very wide fluctuations on either side of its average. It should be understood that where expected variation is referred to in terms of standard deviation, the probability is approximately 2 to 1 against this variation being exceeded.

As the maps include all districts growing wheat (as shown in the Statistical Register) irrespective of the intensity of cultivation, they might to some extent be misleading, e.g., a district shown in the Statistical Register as having a high average yield might in reality be one where comparatively little wheat was grown. The maps have been divided, therefore, into three regions according to the relative

importance of sheep-raising and wheat growing in each region. In region III., the number of sheep carried in each road board district is more than twice as great as the number of acres of wheat harvested for grain, i.e., wheat growing is subsidiary to sheep raising. In region II., this ratio varies from 0.9 to 2.0, i.e., sheep raising and wheat growing are both of importance, while in region I. the ratio is less than 0.9, so that wheat growing is definitely the major activity.

Such a broad classification gives rise to minor anomalies. For example, Dundas and Esperance fall into region III., due probably to sheep carried on pastoral holdings. The wheat farms of the districts could probably be more accurately placed in region I.

It should hardly need to be pointed out that while the various divisions are shown as separated by firm lines, in reality they merge into one another, while even within one subdivision individual farms may be exceptional either as to yield or reliability. These difficulties are inherent in mapping of this sort, and do not invalidate the general picture that is given.

It should be pointed out that the maps and tables give a picture of the average yield and reliability of the districts as shown by the statistics for the past ten years. This period is short and, some might claim, embraces an abnormally high percentage of dry years. Moreover, no attempt is made to analyse the causal factors behind the figures. The yields and their variability have been caused by a complex of factors such as soils, rainfall, farming methods, etc. Any sweeping generalisations as to the comparative value of the districts for wheat growing would therefore necessarily be subject to many qualifications.

TABLE I.

AVERAGE YIELD PER ACRE, 1929-30 TO 1938-39.

<i>Region III.</i>			<i>Region II.</i>		
Districts.		bush.	Districts.		bush.
1. Gnowangerup	...	16.57	1. Quairading	...	14.52
2. Toodyay	...	14.01	2. Carnamah	...	13.84
3. Broomehill	...	13.84	3. Three Springs	...	13.59
4. Beverley	...	13.76	4. Bruce Rock	...	13.57
5. Dumbleyung	...	13.50	5. Goomalling	...	13.08
6. Northam	...	13.40	6. Dowerin	...	12.83
7. Moora	...	13.09	7. Meckering	...	12.55
8. York	...	13.08	8. Corrigin	...	12.00
9. Tambellup	...	12.09	9. Kulin	...	11.88
10. Victoria Plains	...	11.95	10. Lake Grace	...	11.45
11. Mingenew	...	11.70	11. Wickepin	...	11.14
12. Brookton	...	11.60	12. Dalwallinu	...	11.13
13. Wagin	...	11.23	13. Morawa	...	10.40
14. Upper Chapman	...	10.85	14. Perenjori	...	10.11
15. Northampton	...	10.80	15. Mullewa	...	10.05
16. Pingelly	...	10.45			
17. Geraldton	...	10.44			
18. Katanning	...	10.30			
19. Kent	...	10.06			
20. Greenough	...	9.88			
21. Phillips River	...	9.86			
22. Woodanilling	...	9.55			
23. Narrogin	...	9.23			
24. Dundas	...	9.09			
25. Cuballing	...	9.07			
26. Esperance	...	7.80			
			<i>Region I.</i>		
			1. Wyalkatchem	...	12.17
			2. Wongan-Ballidu	...	12.07
			3. Kellerberrin	...	11.85
			4. Narebreen	...	11.60
			5. Kondinin	...	10.85
			6. Kununoppin-Trayning	...	10.75
			7. Merredin	...	10.33
			8. Koorda	...	9.25
			9. Nungarin	...	8.78
			10. Westonia	...	7.93
			11. Mount Marshall	...	7.85
			12. Yilgarn	...	7.03

TABLE 2.

VARIABILITY OF THE YIELD PER ACRE, 1929-30 TO 1938-39.

<i>Region III.</i>				<i>Region II.</i>			
Districts.			%	Districts.			%
1. Dumbleyung ...	...	...	10	1. Quairading ...	...	...	8
2. Kent ...	...	...	12	2. Corrigin ...	...	...	9
3. Katanning ...	...	...	13	3. Kulin ...	...	...	11
4. Brookton ...	...	...	13	4. Dowerin ...	...	...	11
5. Tambellup ...	...	...	13	5. Lake Grace ...	...	...	14
6. Beverley ...	...	...	15	6. Meckering ...	...	...	14
7. Gnowangerup ...	...	...	15	7. Goomalling ...	...	...	14
8. Wagin ...	...	...	16	8. Wickepin ...	...	...	15
9. Moora ...	...	...	16	9. Carnamah ...	...	...	17
10. Broomehill ...	...	...	16	10. Bruce Rock ...	...	...	17
11. Esperance ...	...	...	17	11. Dalwallinu ...	...	...	24
12. Cuballing ...	...	...	17	12. Perenjori ...	...	...	27
13. Woodanilling ...	...	...	17	13. Three Springs ...	...	...	28
14. Narrogin ...	...	...	18	14. Morawa ...	...	...	30
15. Victoria Plains ...	...	...	18	15. Mullewa ...	...	...	41
16. Pingelly ...	...	...	19				
17. York ...	...	...	19				
18. Greenough ...	...	...	22	<i>Region I.</i>			
19. Northam ...	...	...	22	1. Wongan-Ballidu ...	...	...	10
20. Geraldton ...	...	...	24	2. Kondinin ...	...	...	15
21. Toodyay ...	...	...	24	3. Wyalkatchem ...	...	...	17
22. Northampton ...	...	...	25	4. Narembeen ...	...	...	19
23. Dundas ...	...	...	28	5. Kellerberrin ...	...	...	19
24. Upper Chapman ...	...	...	28	6. Kununoppin-Trayning ...	...	...	22
25. Mingenew ...	...	...	33	7. Merredin ...	...	...	33
26. Phillips River ...	...	...	37	8. Koorda ...	...	...	35
				9. Nungarin ...	...	...	42
				10. Mount Marshall ...	...	...	49
				11. Yilgarn ...	...	...	57
				12. Westonia ...	...	...	62

A Note on Green Feed Deficiency Disease.

(AVITAMINOSIS A OF POULTRY.)

L. W. MAHAFFEY, Assistant Veterinary Pathologist.

The term "roup" is still widely employed by Western Australian poultry farmers to describe any disease of domestic birds characterised by whitish cheesy deposits in the mouth and cavities of the head and for "bung eyes," coughing, gasping and related symptoms. It is difficult to bring farmers to realise that this term "roup" includes a number of diseases of very different cause and hence requiring different methods of control. Green-feed deficiency disease is one of the "roup" class. Others are fowl-pox, infectious catarrh and coryza, sinusitis which occurs in turkeys and infectious laryngo-tracheitis, which has never been found in this State.

Green-feed deficiency disease is quite common during the long dry summer period in Western Australia and many birds sent in to the Department for examination each year are found to be suffering from the disease.

As most people know, vitamins are accessory food factors, the presence of which in the food is essential for the normal growth and health of animals. Vitamin A is one of the essential vitamins. Green feed contains precursors to Vitamin A (carotenoid materials) and this is converted by the animal body to Vitamin A, probably in the liver. Good succulent dark green feeds are richest in the carotenoid material which is convertible into Vitamin A. Fats of animal origin like milk, butter, cream, beef-fat and cod-liver oil contain much Vitamin A, and it is present in eggs but not root vegetables and fats of vegetable origin like olive and coconut oils. It is also present in considerable amounts in the liver fat of many animals. Cod-liver or pilchardine oil are the best sources of the Vitamin A for poultry purposes, in the absence of regular supplies of green feed. If birds are deprived of green feed (a source of Vitamin A) or the vitamin itself, then not only does a definite characteristic disease follow in a relatively short time, but egg laying is soon found to drop off, the birds lose condition and their general resistance to many diseases is lowered. Moreover, fertility of the egg is lowered for the hatching season.

Birds Susceptible.

Any domestic birds are susceptible to the disease resulting from inadequate Vitamin A intake. Laying hens show symptoms quicker than cocks, since Vitamin A is present in their eggs and is lost in egg production. Symptoms are shown soon after the body reserves are depleted and this may be as quickly as a month after the elimination of Vitamin A or green feed from the ration. Chicks quickly become ill in its absence, but it is rarely that farmers do not take care to see that the chicks' requirements of green feed are supplied.

Symptoms.

There is first a loss of condition and decrease in egg laying. After a time whitish pustules make their appearance in the mouth cavity, many of these may be observed at both sides of the mouth, and in the throat at the back of the tongue, and commencement of the gullet. As the condition advances these pimples are usually seen extending right down the gullet and on post-mortem are often found as far down as the crop. The eyes become watery and the lids distended with whitish flaky material. Due to the accumulation of this cheesy material in the throat and the pustules in the gullet breathing becomes somewhat difficult. At this stage the bird may be found sitting down, unable to see, with puffed up eyelids, breathing somewhat slowly and periodically raising and lowering the head as it inhales and exhales.

Treatment.

Should the above symptoms be found, in the absence of green feed or a Vitamin A containing supplement, cod-liver or pilchardine oil treatment should be commenced immediately. The sick birds should be caught and dosed individually with about 20 drops of medicinal cod-liver oil daily. At the same time cod-liver oil should be incorporated in the mash daily at the rate of 4 per cent. for the first two days and thereafter at the rate of 1 per cent. The oil should first be mixed

with the bran and this incorporated into the whole mash. The above amounts should not be exceeded.

Prevention.

The condition can be prevented by supplying adequate green feed all the year round; 7 lb. per 100 hens per day is the least amount of green feed which is sufficient or if this is not possible, as in some parts of the State, cod-liver or pilchardine oil must be supplied daily in the mash. These oils are supplied as a "poultry grade" and it is essential that they are up to standard in Vitamin A content. Some oils sold contain quite small amounts of Vitamin A. One per cent. of standard quality oil in the mash daily is sufficient to supply the requirements of the birds and to prevent losses due to Vitamin A deficiency. It is also essential to note that cod-liver and pilchardine oil rapidly lose their Vitamin A on exposure to light and when mixed with bran, pollard, etc. Therefore proprietary ready mixed mashes claiming to supply adequate Vitamin A are to be avoided and the farmer should not mix large quantities of mash with cod-liver oil at one time. It should be mixed as shortly before feeding as is practicable. The oils should be stored continuously in cool, dark places and sealed from air.

In fowl pox another roup disease, often confused with green feed deficiency disease by farmers, the commonest symptoms are the warts on the comb and wattles and in an outbreak most, and always some of the birds, will show these. There are, however, forms known as the diphtheritic (erroneously named avian diphtheria) and oculo-nasal. In the former there is commonly cheesy material in the mouth and throat; this tends to be yellow in colour and of evil odour whereas the cheesy material in green-feed deficiency disease is whiter and not offensive in smell. In the oculo-nasal form there is commonly a nasal discharge which often becomes caseous and fills the sinuses (cavities) of the nose. The same yellowish flaky material may be seen on the eyes. It is to be noted that fowl pox may and does occur when green feed or cod-liver oil is supplied in the ration although its absence renders a bird more susceptible to this condition which is caused by an infective agent known as a virus. Fowl pox then may be superimposed on green-feed deficiency disease. The main differential features for the latter are—

1. The knowledge that no Vitamin A is being provided or that it is inadequate.
2. Pimples or pustules nearly always extend far down the gullet in green-feed deficiency disease (Vitamin A deficiency).
3. In a fowl pox outbreak some or most of the birds will be showing warts on the comb and wattles. If in doubt about a diagnosis an ailing bird should be forwarded to the Veterinary Pathologist of this Department who will make the necessary examination and furnish a report on the condition.

Since green-feed deficiency disease (Vitamin A deficiency or Avitaminosis A) is purely a nutritional disease, it is not infectious and no isolation of sick birds or disinfection is warranted. Fowl pox, of course, is a true infectious disease. In neither case is the removal of the cheesy deposits of any value as a sole measure. If one cleans out the eyes regularly in green-feed deficiency disease, yet provides no Vitamin A, the caseous material will continue to accumulate and death will ultimately ensue. Similarly, medicines and medicated water are useless.

Finally, in connection with the supply of green feed to poultry riboflavine may be mentioned; this is another vitamin (B2) necessary for the growth and health of poultry (and other animals). It is present in small quantity only in

cereal grains and their by-products, and is not present in high quantity in meat-meal or fishmeal. But it is present in considerable quantity in greenstuffs and milk products. Chicks on riboflavine deficient diets show "curled toe paralysis." They walk on their hocks with the toes curled inwards, fail to grow, become emaciated and die. Laying hens may definitely require riboflavine and a large amount is required for egg production and hatchability, which directly depends on the flavine content of the egg, this in turn being determined by the ration supplied.

The Use of Arsenic Compounds for Killing Green Timber.

G. R. W. MEADLY.

Ringbarking plays a very big part in the killing of trees during clearing operations, but the results of hard work are often disappointing owing to the formation of an abundance of suckers following the ringing. This sucker formation can be reduced to a large extent or entirely eliminated by the use of certain compounds of arsenic. These chemicals have also the effect of killing the trees quicker, those taking months to die when ring-barked often reaching the same condition in a few weeks, following the application of a suitable chemical. The actual time taken for the timber to become dry, however, after the tree is dead is not affected appreciably.

CHEMICALS USED.

Compounds of arsenic are by far the most commonly used chemicals for killing green timber, sodium arsenite and arsenic pentoxide being used to a considerable extent for this purpose. Until comparatively recently all the treatment was done with sodium arsenite but during the last two or three years the use of arsenic pentoxide has increased until it is now more favoured than sodium arsenite in New South Wales. As little other than the arsenite is used for killing green timber in this State, some information received recently from the New South Wales Weeds Officer (Mr. K. G. Carn), is of considerable interest.

He states that until some two years ago, sodium arsenite was practically the only chemical used for green timber work in New South Wales. Queensland experience indicated that arsenic pentoxide was worth trying and now it has largely superseded the arsenite. The pentoxide appears to have greater penetrating power, an important factor when large scale operations are being carried out by contract and the ringing may not always be complete. In recent experiments mallee destruction has been undertaken by pouring the pentoxide into one single chop on the side of the mallee.

Mr. Carn concludes from experiments in many parts of the State that where timber is easy to kill there is no material difference in the value of the arsenite and pentoxide but with those trees showing a greater tendency to sucker the pentoxide is much more efficient.

PREPARATION.

Arsenic pentoxide.

This chemical is sold in a granulated form which is readily soluble in water. The solution of the required strength for killing green timber is made by dissolving three pounds of the chemical in five gallons of water.

Sodium arsenite.

Sodium arsenite can also be purchased and is soluble in cold water, being mixed in the proportion of one pound to two gallons. The cost can be reduced by preparing the solution from one pound white arsenic and $\frac{1}{2}$ pound caustic soda and four gallons of water. The solids are thoroughly mixed and then about an equal quantity of water added. Upon the addition of the water sufficient heat is produced to rapidly dissolve the solids. Further water is then added to make up the four gallons.

A still cheaper method of preparation is to replace the caustic soda by twice the quantity, i.e., one pound of washing soda, but boiling is necessary to dissolve the white arsenic. The soda is first dissolved in a convenient quantity of water, using heat if necessary to hasten the solution. The white arsenic is then mixed into a paste with water and added slowly to the soda solution, stirring all the time. This is placed on a strong fire and boiled for at least one hour, stirring from time to time. When all the arsenic is dissolved the solution is made up to the required bulk by adding the necessary amount of water. One half pound of whiting, first mixed into a paste, is often added to each four gallons of these arsenical solutions in order that the treated trees can be detected easily.

METHOD OF APPLICATION.

My means of a series of downward strokes, "frill ring" the trees as close to the ground as possible. By making the axe strokes in one direction only and cutting into the heart wood, a frill is formed into which the solution is poured as soon as possible after the tree has been cut. For trees of four feet in diameter about one quart is required, the quantity varying according to the size of the tree.

Containers with spouts, such as old kettles or large teapots are convenient for pouring the solution into the frill, but the most efficient method is to have a container of the knapsack type strapped to the back and fitted with a piece of tubing having a tap at the end.

Saplings may be treated somewhat differently by severing them as low as possible and swabbing the cut surfaces by means of a swab stick.

In order to secure satisfactory results the work must be carried out in a thorough manner. If the frill is not complete or the solution not poured around the whole of the frill, the best results cannot be expected, especially when using sodium arsenite.

TIME OF APPLICATION.

Best results have been secured when the trees are dormant, i.e., when upward sap movement is at its minimum. At this stage the tendency to sucker following injury is least pronounced. Although the time of this condition varies with different trees and also with different climatic and edaphic conditions, in the South-west of this State most of the work is carried out between June and September.

COST OF MATERIALS.

Mention was made earlier of the relative cost of the different chemicals which can be used. As these fluctuate to a certain extent, if quantities are required quotations should be secured from wholesale chemists.

WARNING.

Avoid inhaling the fumes, as far as possible, owing to their unpleasant and injurious nature. Rubber gloves provide an excellent safeguard for the hands against both the arsenic and the caustic effect of the soda.

The chemicals, both in the solid form and in the solution, must always be regarded and treated as virulent poisons. Vessels used for mixing or applying the solution should be reserved strictly for those purposes and carefully stored when operations have been completed. Children are only too ready to taste things and cows are always interested in empty buckets.

Animals eat the twigs and leaves of treated trees without ill effects, but should be withheld from the paddocks for at least three weeks after application as they may lick the poisoned section of the trunk. Rains reduce this period of risk.

Fertilisers Containing Copper.

Superphosphate-Bluestone Mixtures Now Available.

Farmers are advised that fertiliser firms in this State are now marketing a mixture of superphosphate and bluestone (copper sulphate) for the convenience of farmers who are cultivating land known to be copper deficient. One ton of the mixture contains one hundredweight of bluestone and the price is £7 5s. per ton. When used at the rate of 100 pounds per acre this mixture supplies five pounds per acre of bluestone, which is considered sufficient for copper deficient land in the wheat belt.

In the wetter areas where pasture topdressing is commonly at the rate of one bag per acre the bluestone application using this mixture will be about nine pounds per acre. The registered analysis of the superphosphate and copper fertilisers will be found on page 30.

Experiments with Micro-Elements for the Growth of Crops in Western Australia.

1. EXPERIMENTS IN THE WHEAT BELT WITH CEREALS.

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SUMMARY.

Experiments have been carried out to determine the response of crops to copper-containing fertilisers on a variety of soil types in the Gingin and Dandaragan districts and the wheat belt.

Data are given showing, in a number of cases, important yield increases where copper-containing fertilisers have been applied.

Of particular interest and importance is the discovery of considerable benefit from the use of copper on wadjil country on a number of farms in the wheat belt.

Oxidised copper ore from Ravensthorpe and roaster residues from pyrites burners have been used in comparison with bluestone. In a number of instances the copper ore has proved superior to bluestone and in some cases the roaster residues have produced the best crop.

The superiority of these amendments points to the possible importance of other elements in crop fertilisation on these soil types.

Analyses of oats in the early growth stages—not later than six weeks after planting—may give an indication of acute copper deficiency in soils. At later stages analyses of oats from control strips on acutely deficient land are the same as from adjacent copper treated strips. Subterranean clover seems more useful as an indicator as substantial differences are observed between the copper content of the leaves from control areas on acutely deficient land as compared with adjacent copper treated areas. From the samples of cape weed analysed there is no indication that this plant would serve as an indicator of copper deficiency.

I. INTRODUCTION.

The spectacular response of an oat crop to bluestone as a fertiliser at Dandaragan has been reported by Teakle, Turton and Throssell (1940). This work has been extended to a number of other sites in the Dandaragan district and at Gingin. In other parts of the wheat belt, during the 1940 season, exploratory experiments with copper containing fertilisers have been carried out on poor sandy and gravelly country of the wodjil* type with very encouraging success. Other experiments were arranged in 1939 in association with stalling of clover investigations in the Great Southern area. These failed to give any indication of special deficiencies. One experiment of this series at the Merredin Research Station on wodjil country shows the harmful effect of small quantities of certain micro-elements on sandy and gravelly soils.

The two series of experiments carried out in 1940 were designed to detect further areas responding to micro-element fertilisers and to determine the value of other sources of copper which may prove cheaper and perhaps more accessible than the refined bluestone. Relatively low grade oxidised copper ore containing from 18 to 19 per cent. copper (Cu) was obtained from Ravensthorpe and Messrs. Cuming Smith & Mt. Lyell Farmers Fertilisers Ltd. kindly made available a quantity of finely ground roaster residues from their Bassendean works.

The copper ore has not yet been examined completely but the report of the Government Mineralogist and Analyst gives the following information:

Total copper (Cu)	18.9	per cent.
Cu as sulphide	1.84	per cent.
Cu soluble in 5 per cent. acetic acid	17.06	per cent.

Malachite, azurite, cuprite and chrysocolla may contribute to the acetic acid-soluble fraction."

In the preparation of the copper ore for use in these experiments it was first ground to a suitable fineness. For one treatment this ground material was simply mixed with superphosphate and applied at a rate equivalent in copper content to 15 lbs. of bluestone (25% copper (Cu)) per acre. For other treatments the ground ore was treated with sulphuric acid, dried, ground again and then mixed with superphosphate. This mixture was applied at two rates—one equivalent in copper application to 5 lbs. of bluestone per acre and the other to 15 lbs. of bluestone per acre.

* The Government Botanist (Mr. C. A. Gardner) advises that the term wodjil, as popularly used, does not refer to any particular plant but to the dominant species in the plant community on types of sandy and gravelly soils in the wheat belt. The principal species commonly called wodjil include *Acacia signata* (chiefly in the south), *A. Beaverdiana* (chiefly in the north and north-east), *A. neurophylla* (generally on very gravelly soils), *Hakea multilinea* and *Casuarina acutivalvis*.

The roaster residues are a by-product of the period when pyrites were burnt as a source of sulphur in sulphuric acid manufacture. The approximate composition of this material is as follows*:

	Total %	Water Soluble. %
Copper (Cu)	2.2	0.77
Zinc (Zn)	2.8	2.34
Manganese (Mn)	0.027	0.013

In addition the residues contained about 66 per cent. Fe_2O_3 , from 0.15 to 0.42 per cent. antimony (Sb), 0.033 to 0.02 per cent. arsenic (As), and, probably, traces of other elements which may be of some importance nutritionally.

Similar roaster residues have been used successfully in Germany on copper deficient soils. (Nicolaisen, W., Seelbach, W., and Leitzke, B., 1939). Analysis of the German material shows the micro-element content to be:

Constituent.	Range per cent.
Zinc (Zn)	0.8 — 4.8
Lead (Pb)	0.4 — 0.8
Copper (Cu)	0.4 — 0.5
Nickel (Ni)	about 0.02
Cobalt (Co)	0.08
Manganese (Mn)	0.4 — 1.2

In the German work the best yields of oat grain were obtained from dressings of the order of magnitude of 16 cwt. to 32 cwt. of roaster residues per acre, lighter dressings being less effective. Furthermore, the material seemed to promote better vegetative growth of oats than bluestone and was far superior with respect to grain production; with lupins and rye there was little difference between the effect of the roaster residues and the bluestone.

It is probable that the copper ore and roaster residues used in the present experiments contain elements other than copper which will be of nutritional value on certain soil types and the effect of these amendments may not be identical with refined bluestone.

The season proved abnormally dry and drought conditions prevailed over much of the wheat belt. The reduced rainfall favoured certain of the Gingin and Dandaragan plots but was responsible for low yields in many other areas.

Rainfall records for representative centres are given in Table 1.

TABLE 1.
RAINFALL RECORDS FOR THE 1940 SEASON AT REPRESENTATIVE CENTRES.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total..
Merredin Research Station	6	....	2	10	38	126	136	15	55	132	28	186	734
Kununoppin	1	....	1	21	34	123	163	9	83	108	....	186	729
Dowerin	48	....	....	4	71	209	207	52	114	129	14	176	1,024
Gingin	167	2	5	19	175	364	365	171	223	238	45	130	1,904
Dandaragan	101	9	3	17	234	358	446	156	273	189	50	153	1,989

*Mr. J. Cuming private communication May 28th, 1940.

II. EXPERIMENTS AT DANDARAGAN AND GINGIN, 1940.

Experiments were arranged on Mr. J. A. V. Brown's property, Bidgerabbie, Mr. C. J. Roberts' property, Kayanaba, Messrs. T. Barrett-Lennard, Wedge and Kyle's property, Yaodabbie and Mungedar Pastoral Company's property, Mungedar, in the Dandaragan district, and on Mr. V. G. Rennie's property, Moondah, Gingin. The following notes regarding the conditions at the site of each experiment are pertinent.

a. Mr. J. A. V. Brown's property, Bidgerabbie.

The soils of this site have been discussed by Teakle, Turton and Throssell (1940). Briefly the area may be described as a blue gum (*Eucalyptus rudis*) flat, apparently of lacustrine formation. The soils, grey to brown in colour, are very light and powdery in nature and the mineral matter is made up largely of fragmental diatomaceous and spicular remains mixed with a certain amount of sand.

The land was ploughed with the first autumn rains and sown with Mulga oats and the appropriate fertiliser mixtures during the first week in June. Germination was somewhat delayed and weeds, particularly silver grass (*Festuca myuros*), heavily infested the land. The dry season did not suit this type of soil and the crop growth was less vigorous than in the 1939 season.

b. Mr. C. J. Roberts' property, Kayanaba.

The area selected for the experiment lies just west of the homestead. In the virgin state it had carried scrub, including a prickly *Hakea*, in contrast with the usual forest of marri, etc. The soil was reasonably uniform in profile and, apart from a tendency to waterlog in patches during wet periods, is of a type which would be expected to carry satisfactory crops. The principal features of the profile are a surface of one foot of grey brown loamy sand with a brown sandy subsurface layer to a depth of 2 to 4 feet. Below this is a dark grey brown clay which sometimes shows a greenish tinge. The reaction of the surface soils ranged from pH 5.2 to 5.4 and was generally above pH 6 in the subsoil layers. However, the area had proved unsatisfactory for cereals and mineral deficiency was suspected.

For the experiment, the area was ploughed on June 4th-6th and sown with Algerian oats and the appropriate fertiliser mixtures on June 7th-10th, 1940. Growth was generally satisfactory but a severe infestation with wild radish (*Raphanus raphanistrum*) interfered. The low rainfall suited the conditions on these plots.

Unfortunately, owing to a misunderstanding, the northern buffer was sown too wide and the plots had to be shifted south to such an extent that four fell on a different soil type, marri or red gum country known as the Whakea sand (see Hosking and Greaves, 1936) on which the growth was different. Consequently, in Table 2, the yields of the treatments are given both including and excluding these four plots.

c. Messrs. Barrett-Lennard, Wedge and Kyle's property, Yaodabbie.

An area of recently cleared land was made available on Yaodabbie for experimental purposes. The land had carried marri, banksia, and scrub and the soils ranged from red coarse sands and sandy loams, with gravelly patches, of the

Whakea series, to brown sands of lower fertility and related to the Koorian series of Gingin. (Hosking and Greaves, 1936).

After cultivation in May 1940 the experiment was drilled on June 6th and 7th, 1940. When the roughness of the ground was taken into consideration the general growth of the oats was deemed satisfactory but was rather uneven.

d. Mr. V. G. Rennie's property, Moondah, Gingin.

The site selected on Moondah was old land which had been cultivated periodically for many years. In the virgin state the land had carried marri and banksia. The soils were generally red sands and sandy loams of the Whakea series but on the eastern end became lighter in colour and texture and approached the Koorian series in character. (See Hosking and Greaves, 1936). Patches of ironstone gravel were observed on portions of the Whakea types.

Generally crops on the Whakea types have been satisfactory, often heavy, but on the lighter soils growth has always been inferior. Although in a copper deficient area for stock (Bennetts and Chapman, 1937) copper deficiency of oats had not been observed or suspected.

In preparation for the experiment the area was ploughed in early June and planted with Guyra oats and the appropriate fertilisers on June 5th and 6th, 1940.

Over the experimental area growth was generally satisfactory except on the eastern portion where the crop was generally light. A heavy infestation of wild radish interfered with growth to some extent.

e. Mungedar Pastoral Co., North Dandaragan.

The plots were sown with oats and the various fertilisers across a variety of soils in the northern portion of the station and were designed for exploratory purposes only.

The soils ranged from reddish gritty sand at the west end to dark grey sandy and clayey soil of the rendzina type (formed on chalk) in the centre and grey brown sand of only fair fertility at the east end.

On the reddish sandy country of the west end the oat crop was quite good. The roaster residues gave the best growth and the superphosphate only the poorest. No distinctive symptoms were apparent.

On the dark grey rendzina soil the oats ranged from very poor to fair on the superphosphate only plots. Leaf tipping was severe and in parts the plants had died out without producing heads. Very strong growth occurred on the plot receiving dissolved copper ore with the superphosphate and where the slag was used the crop was exceptionally heavy and up to 5½ feet tall.

On the grey brown sand of the east end the crop was fair on the roaster residues and dissolved copper ore plots, but very poor with superphosphate alone.

The yields from the treatments were as follows:

Treatment.	Bushels per Acre.
1.—Control—superphosphate	20.6
2.—Superphosphate and dissolved copper ore equivalent to 15 lbs. of bluestone per acre	34.1
3.—Superphosphate plus roaster residues equivalent to about 15 lbs. of bluestone per acre	41.2

Observations During Progress of Experiments.

The main experiments were inspected on July 22nd-23rd, 1940. At Moondah the control plots (receiving superphosphate only) were showing the initial signs of copper deficiency in the form of a slight yellowness of the base of the leaves and some stringy tipping of the first leaves. These deficiency symptoms were more advanced at Kayanaba and Bidgerabbie. In fact, on one small area at Kayanaba, the oats were already beginning to die back due to severe copper deficiency. No deficiency symptoms were observed at Yaodabbie but bluestone at the rate of 15 lbs. per acre had obviously reduced early growth. There was generally less growth on the plots receiving no superphosphate.

Later inspections showed that further copper deficiency symptoms did not develop at Moondah but the copper treatments appeared to have improved growth. At Bidgerabbie, the control plots failed almost completely and the increasing rates of copper application (ranging from 1 to 5 lbs. of bluestone per acre) were associated with corresponding improvement in the growth of the oats. Copper deficiency symptoms persisted at Kayanaba. Certain patches were very badly affected but generally the deficiency appeared to be mild. At no time were distinctive copper deficiency symptoms observed at Yaodabbie. However, the plots receiving roaster residues were superior in appearance at all later inspections and yield data (Table 3) show a substantial improvement in production where this amendment was used. While the plots treated with bluestone appeared similar to the controls, grain production was better but not equal to the roaster residues plots. The dressing with 5 lbs. of bluestone per acre in addition to the usual superphosphate at Bidgerabbie seems much inferior to the copper ore and roaster residues and about equal to 15 lbs. of bluestone per acre without superphosphate. It is possible that the adverse seasonal conditions were responsible for the less satisfactory yield from bluestone at the rate of 5 lbs. as, in 1939, there was nothing to choose between 5 lbs., 15 lbs., and 30 lbs. of bluestone per acre.

Of course it is possible that some other constituents of the copper ore and the roaster residues are effecting improvement in yield in the cases of Bidgerabbie and Yaodabbie. This may be important, more particularly with respect to the roaster residues, as field inspection in both cases revealed a more attractive golden yellow colour of straw and glumes where the roaster residues had been used. Furthermore, by far the best single plot on Kayanaba from the point of view of appearance and yield was that dressed with roaster residues. At Mungedar, likewise, the plot receiving roaster residues was the best. The present information does not point to the nature of this possible secondary factor, but the observation may be of particular importance in animal and plant nutrition in the Dandaragan District.

In each case it was not convenient to obtain yields by means of a harvester. Consequently, from 8 to 10 quadrats, at least 1 square yard in area, were cut by hand from each plot at about 1 chain intervals. The small sheaves representing each plot were bulked, threshed and the grain separated by means of sieves and an electric fan in the laboratory. Bushel weights were determined by means of a small chondrometer. As the samples were threshed by hand a considerable amount of whisker remained on the oats and packing was much more open than with machine harvested grain. The bushel weight figures are deemed to be of value in indicating, not absolute values, but the comparative quality of the grain from the various treatments. Unfortunately, material from the Moondah plots was attacked by mice and some loss occurred in a number of samples.

TABLE 2.
YIELDS OF OATS FROM PLOTS UNDER VARIOUS FERTILISER TREATMENTS AT BIDGERABBIE, KAYANABA
AND MOONDAH, 1940.

No.	Treatment.				Roberts, Kavanaba.		Rennie, Moondah.	
	Variety	Date Sown	Date Harvested	Bushels per acre.	Brown, Bidgerabbie.		Excluding 4 Plots on different Soil Type.	
					Mulga Early June 27th-28th November	Algerian 7th-10th June 4th-5th December	All Plots.	Algerian 7th-10th June 4th 5th December
1	Control—Superphosphate 1 cwt. per acre	....	....	....	Bushels per acre.	Bushel wt. lbs.	Bushels per acre.	Bushel wt. lbs.
2	Control plus 1 lb. bluestone per acre—Brown	....	....	1.1	19	33	17.1*	32
3	2½ lbs. bluestone per acre—Brown	....	....	10.1	23	....	....	....
4	5 lbs. bluestone per acre—Brown	....	....	17.0	26	....	....	....
	15 lbs bluestone per acre—Roberts & Rennie	....	....	20.4	26	32	27.6	32
	bluestone and manganese sulphate each 15 lbs. per acre, ferrous sulphate and magnesium sulphate each 20 lbs per acre, zinc sulphate and borax each 5 lbs. per acre—Roberts & Rennie	....	....	....	....	33	27.8	32
	Control plus dissolved copper ore equivalent to 15 lbs. bluestone per acre	....	....	....	....	32	26.3	32
5	Control plus dissolved copper ore equivalent to 5 lbs. bluestone per acre	....	....	28.4	30	33	32.0	34
6	Control plus dissolved copper ore equivalent to 15 lbs. bluestone per acre	....	....	31.1	31	32	28.1	34
7	Control plus ground copper ore equivalent to 15 lbs. bluestone per acre	....	....	30.9	31	32	27.1	34
8	Control plus 200 lbs. roaster residues per acre—equivalent to about 15 lbs. bluestone per acre	....	....	30.1	30	33	32.9	33
9	15 lbs. bluestone per acre	....	....	23.9	30	33	23.5	31
	Difference for significance at P .05	....	....	8.5	2.7	....	....	....

* Some loss of sample from one plot in each block due to attack of mice. † Yield from one plot in each block lost.

The yield data are given in Tables 2 and 3.

TABLE 3.

YIELD OF OATS (BURT'S EARLY) FROM PLOTS UNDER VARIOUS FERTILISER TREATMENTS ON BARRETT-LENNARD, WEDGE & KYLE'S PROPERTY, YAODABBIE, DANDARAGAN.

Planted 6th-7th June, 1940. Harvested 30th November, 1940.

Treatment.					Yield.	Bushel Weight.
					bushels per acre.	lbs.
Control—superphosphate, 1 cwt. per acre	...	...	...	...	9.2	29
Control plus bluestone, 15 lbs. per acre	...	...	...	...	12.8	32
Control plus roaster residues, equivalent to bluestone	...	...	...	...		
about 15 lbs. per acre	...	...	...	...	16.2	32
Bluestone, 15 lbs. per acre	...	...	...	...	12.2	30
No fertiliser	...	...	...	...	9.2	28

These data show that copper is of paramount importance on the blue gum flat soils at Bidgerabbie. Even the small yield of grain from the control plots represents small patches where some maturation occurred, but the grain was almost entirely empty husk. The best grain on this farm, as shown by the bushel weights, was from the copper ore and roaster residues plots. On Kayanaba bluestone has increased grain yields by about 40 per cent. and the copper ore and roaster residues by 60 to 70 per cent. as compared with the control. Copper containing fertilisers have produced at least a 30 per cent. improvement in grain yield at Moon-dah. Bluestone has given a 40 per cent. and roaster residues a 75 per cent. increase in grain yield at Yaodabbie. Considerable increases were obtained at Mungedar. (See page 74.)

The yields of total produce, grain plus straw, were obtained from Bidgerabbie and Yaodabbie. From this information the grain : straw ratios have been calculated and are reported in Table 4, with the yields of these fractions.

These data show that, on Bidgerabbie, there is little effect on the production of straw from the different rates of bluestone and the kinds of copper supplying ingredients. The principal effect is on grain production. Where the copper supply is adequate, the grain amounts to about 50 per cent. of the straw weight, but the ratio is reduced as the amount of copper supplied falls off. In this experiment 5 lbs. of bluestone per acre or an equivalent copper application as dissolved copper ore has failed to promote normal grain formation according to the standard set by the higher rates. In the 1939 experiment on this property 5 lbs. of bluestone per acre appeared equal to 15 and 30 lbs. per acre with respect to grain production. It is thought that the different seasonal conditions are responsible for the changed response. Apparently bluestone at the rate of 5 lbs. per acre is a sufficient dressing for this land in a satisfactory season but is sub-optimal for grain production, when the conditions are somewhat adverse.

The information from Yaodabbie also shows the effect of the copper containing fertilisers in promoting grain production.

TABLE 4.

YIELDS OF TOTAL PRODUCE, GRAIN AND STRAW AND THE GRAIN : STRAW RATIOS UNDER THE VARIOUS FERTILISER TREATMENTS USED ON MR. BROWN'S PROPERTY, BIDGERABBIE, AND MESSRS. BARRETT-LENNARD, WEDGE AND KYLE'S PROPERTY, YAODABBIE.

No.	Treatment.	Yield per Acre.			Grain : Straw.
		Total Produce.	Grain.	Straw.	
BIDGERABBIE.					
1	Control—superphosphate 1 cwt. per acre ...	lbs. 914	lbs. 44	lbs. 870	% 5
2	Control plus 1 lb. bluestone per acre ...	3,034	404	2,630	15
3	Control plus 2½ lbs. bluestone per acre ...	3,131	680	2,451	28
4	Control plus 5 lbs. bluestone per acre ...	3,598	816	2,782	29
5	Control plus dissolved copper ore equivalent to 5 lbs. bluestone per acre ...	4,123	1,136	2,987	38
6	Control plus dissolved copper ore equivalent to 15 lbs. bluestone per acre. ...	3,695	1,244	2,451	51
7	Control plus ground copper ore equivalent to 15 lbs. bluestone per acre. ...	3,675	1,236	2,439	51
8	Control plus 200 lbs. roaster residues per acre, equivalent to about 15 lbs. bluestone per acre ...	3,578	1,204	2,374	51
9	15 lbs. bluestone per acre ...	2,917	956	1,961	49
YAODABBIE.					
1	Control—superphosphate 1 cwt. per acre ...	1,677	368	1,309	28
2	Control plus 15 lbs. bluestone per acre ...	1,604	512	1,092	47
3	Control plus roaster residues equivalent to 15 lbs. bluestone per acre ...	2,086	648	1,438	45
4	Bluestone 15 lbs. per acre ...	1,517	488	1,029	47
5	No fertiliser ...	1,480	368	1,112	33

III. EXPLORATORY EXPERIMENTS WITH COPPER-CONTAINING FERTILISERS.

Through the courtesy of Messrs. Cuming Smith & Mt. Lyell Farmers' Fertilisers Ltd. a number of parcels of roaster residues and superphosphates mixed with dissolved copper ore were made available for use on farms in the wheat belt. The fertilisers were to be applied at a rate equivalent to 15 lbs. of bluestone per acre. Farms were selected from which complaints regarding the occurrence of dummy heads in wheat had been received as it was thought that copper might have been a factor in certain cases. Stewart and Teakle (1939) have reported experiments at Wagin showing the successful use of copper on gravelly soil where dummy heads are common under ordinary fertiliser practice. In most cases the soils selected for test were of the wadjil type. Generally these soils range from greyish yellow sands to gravelly sands and are recognised to be of low productivity and liable to produce dummy heads.

In these tests the two copper-containing fertilisers and controls with superphosphate only were drilled in long strips across the selected paddock, taking care that patches of the unsatisfactory soil types were crossed. Some initial damage from the dissolved copper ore was noted in most cases and, until heading out, these plots appeared inferior. However, in a number of cases the superphosphate

only strips failed to form grain on the wodjil type of country, whereas normal heads, well filled with good grain, were produced where copper was applied on adjacent strips. Where the strips crossed the better classes of land the crop appeared to receive no benefit from the special treatments.

Results from farms from which observations and yield data are available are given in Tables 5 and 6.

TABLE 5.

RESULTS OF EXPLORATORY TESTS WITH COPPER-CONTAINING FERTILISERS FOR THE GROWTH OF WHEAT AND BARLEY IN THE WHEAT BELT.

Farmer.	District.	Crop.	Type of Land.	Control—Super-phosphate only.	Control plus dissolved copper ore.	Control plus roaster residues.
S. Williams (loc. 9016)	Hindmarsh (Dowerin)	wheat	Wodjil—gravelly sand with gravelly hardpan	Bushels per acre. 1.5	Bushels per acre. 8.8	Bushels per acre. 9.9
W. Clarke (loc. 1548)	Cadoux ...	wheat (Bencubbin)	Wodjil—gravelly sand—5 chains	4.3	7.6	4.3
			Rest of paddock—23 chains	9.6	9.4	9.4
G. L. Herley ...	Gunyidi ...	barley	Heath—yellowish sandy soil some feet deep	13.8	12.1	13.1
F. P. Squires ...	Watheroo ...	barley	Mallee—brownish grey sand with clayey subsoil	4.5	4.4	5.1
H. H. Diprose ...	Dongarra ...	wheat	Grey brown to brown calcareous sandy soil on coastal limestone	No discernible differences.		
M. Ferries ...	Dongarra ...	wheat	Dark grey calcareous sandy soil on coastal limestone	No observable effect from dissolved ore—roaster residues strip appeared superior—not harvested.		
G. M. Appleyard (loc. 15547)	Kununoppin	wheat	Wodjil—brownish yellow gravelly sand	Marked improvement from dissolved copper ore and roaster residues.		
J. W. Kahl (loc. 11856)	Kununoppin	wheat	Patch 1 chain long of greyish yellow brown sand in salty morrel country	Marked improvement where copper used on sandy patch. No differences elsewhere.		
Creagh Bros. ...	Nungarin ...	wheat	Tamma scrub ...	Failed on account of drought. No observed effects from treatments.		
B. W. G. Hopwood	Bencubbin...	wheat	Mallee and scrub	Failed on account of drought. No observed effects from treatments.		

TABLE 6.

RESULTS OF EXPLORATORY TESTS WITH COPPER-CONTAINING FERTILISERS FOR THE GROWTH OF WHEAT ON MR. C. SMART'S PROPERTY, LOC. 15778, MINNIVALE.

Treatment.	Copper Application equivalent to Bluestone.	Yield per acre.	Bushels Wt.
	lbs. per acre.	bushels per acre. New land.	bushels per acre. Old land.
Control—super.*	<i>Nil</i> *	3.6	3.9
Bulk crop—super.	<i>Nil</i>	0.6	0.9
Super. plus manganese sulphate ...	<i>Nil</i>	0.2	1.4
Super. plus copper ore	15	2.2	5.8
Super. plus bluestone	10	3.8	6.6
Super. plus bluestone, manganese sulphate	10	3.0	6.9
Super. plus roaster residues	15	1.3	3.7

* While the bulk crop and other plots receiving no copper were very poor and showed copper deficiency symptoms, this control appeared normal and resembled copper treated portions. It is possible that copper was included in the fertiliser by mistake in the case of this control plot.

These data show that copper is effective in improving yields on some types of country subject to dummy heads in wheat. It is probable that many farmers will be able to use this discovery and, by dressing patches of such wadjil country in their cleared paddocks, avoid the waste of hauling agricultural machinery over more or less sterile crop. In the case of Mr. Smart, the results will apply to several hundred acres, and Mr. Clarke and Mr. Williams are farming something less than a hundred acres of such types.

The response on the dark grey calcareous sand of Mr. Ferries' property, Dongarra, indicate that copper is probably not a primary factor. Perhaps zinc, as discovered in South Australia, is the element of prime importance in this case.

IV. EXPERIMENTS AT THE MERREDIN RESEARCH STATION AND GREAT SOUTHERN CENTRES, 1939.

Following the work at Wagin (Stewart and Teakle, 1939) and at Albany, a number of experiments were laid down on convenient sites to determine the effect of micro-elements on the growth of cereals on soils which had proved unsatisfactory for one reason or another.

In each of these experiments the fertiliser treatments included (1) superphosphate as control, (2) superphosphate plus bluestone—15 lbs. per acre, (3) superphosphate plus manganese sulphate—15 lbs. per acre, (4) superphosphate plus copper, manganese and zinc, and (5) superphosphate plus copper, manganese, zinc, boron, magnesium and iron.

On the Merredin Research Station the soil selected was of the wadjil type and was reported to be quite unsuitable for wheat. Rye was known to be a more satisfactory cereal crop. The soils ranged from a greyish yellow sand to a very

gravelly sand and in appearance conformed to the features commonly associated with disappointing wheat crops. In this instance, the land had not been under wheat for many years and was in good condition after being well fallowed in 1938.

Throughout the growing season the wheat on the control plots and those receiving manganese sulphate appeared similar and made very satisfactory growth. In fact, the growth was far better than expected. The bluestone and copper plus manganese plus zinc plots showed signs of impaired germination and delayed growth while the fifth treatment proved very harmful to the wheat. It was stated that these plots resembled fallow until the end of July. No distinctive symptoms were observed on any of the plots but the yellow tipping of younger leaves and the general yellowing of the older leaves, so characteristic of light land crops, were common to all plots.

Yield data are given in Table 7 and show the satisfactory returns on the controls and the harmful effects of certain other treatments.

The plots on the Narrogin School of Agriculture were laid down on poor sandy and gravelly country which, in the virgin state, had carried marri and scrub. Portion of the area proved liable to waterlogging in wet periods. The area was known to be very unsatisfactory for cereals and had proved difficult for pasture establishment.

Oats were used for this experiment. Throughout the growing season growth was poor and no responses to fertiliser treatment were observed. The yield of grain was very low and showed no relation to treatment.

Yield data are given in Table 7.

On Mr. F. E. Hitchins' property, Cranbrook, the same series of plots was laid down on two sites.

1. On Peacock's paddock the area selected was the site of an old orchard and had given very patchy and unsatisfactory growth of barley and oats in 1938. Deficiency troubles were suspected. Like the crop, the soils were very variable over the small area and ranged from a rich brown sandy loam with a tough brown clay subsoil to a grey coarse gritty sand with yellow, brown and grey mottled gritty clay subsoil. The brown types are associated with granitic and basic rocks and boulders, and are of much higher fertility than the grey types. Yate appeared to predominate on the brown types and wandoo and sheoak on the grey types.

The growth of the oats on the area was very patchy and again the best growth was on the brown soil types. No response to treatment was observed or is indicated by the yield data in Table 7.

2. East of the homestead the site selected had been under subterranean clover for about 12 years but severe stalling had occurred and only a very poor pasture mixture, largely *Erodium botrys*, persisted at the time the experiment was arranged. In 1938 portion of the area had been sown to barley but the growth was most disappointing and again mineral deficiency was suspected. In preparation for the oat crop the land was cultivated after the first autumn rains in 1939 and sown to Lachlan oats and the appropriate fertilisers, on May 23, 24, and 25, 1939. Apart from some early damage from red legged earth mite and a severe frost, growth generally was satisfactory and fairly uniform over most of the area. No distinctive symptoms were observed, no differences related to the treatments could be detected and, at harvest, an excellent yield of grain was obtained. The yield data, reported in Table 7, show no effect from the treatments.

TABLE 7.

YIELDS OF GRAIN IN CONNECTION WITH EXPERIMENTS WITH CEREALS ON
F. E. HITCHINS, CRANBROOK, THE NARROGIN SCHOOL OF AGRICULTURE
AND THE MERREDIN RESEARCH STATION, 1939.

In each case the treatments were as follows :—

1. Control—superphosphate, 1 cwt. per acre.
2. Control plus bluestone, 15 lbs. per acre.
3. Control plus manganese sulphate, 15 lbs. per acre.
4. Control plus bluestone, 15 lbs. per acre.
manganese sulphate, 15 lbs. per acre.
zinc sulphate, 5 lbs. per acre.
5. Control plus bluestone, 15 lbs. per acre.
manganese sulphate, 15 lbs. per acre.
zinc sulphate, 5 lbs. per acre.
borax, 5 lbs. per acre.
magnesium sulphate, 20 lbs. per acre.
ferrous sulphate, 20 lbs. per acre.

Treatment No.	Merredin Research Station. Wheat.	Narrogin School of Agriculture. Oats.	F. E. Hitchins, Cranbrook.	
			Near homestead, Oats.	Peacock's paddock, Oats.
	Bushels per acre.	Bushels per acre.	Bushels per acre.	Bushels per acre.
1	12·7	4·7	36·5	13·0
2	9·0	3·9	42·4	14·3
3	13·0	5·4	40·3	12·7
4	6·8	4·5	42·3	13·5
5	4·4	3·8	45·7	12·8

These figures give no evidence of specific mineral deficiency at any site. It is possible that further cropping with wheat at the Merredin site will result in decreased yields on the control plots and that smaller dressings of micro-elements may promote the maintenance of productivity. At Narrogin, the deficiency may be more complex and a different line of attack required to solve the problem. The same conclusion may be derived from the results on the grey soil type on Peacock's paddock, Cranbrook. With respect to the site near Mr. Hitchins' homestead it is apparent that, irrespective of special fertiliser treatment, an excellent crop of oats was produced when the cultural and environmental conditions were satisfactory. It may be thought that the difference of 9 bushels per acre between the control and treatment 5 would be significant, but statistical treatment of the results showed that plot variability was so great that this may not be so. While the difference may indicate a benefit from a micro-element or combination of micro-elements, this is by no means certain and the results leave the stalling of clover problem at Cranbrook as obscure as ever.

V. COPPER CONTENT OF PLANT MATERIAL.

It would be of very great advantage if soil analysis would give a reliable measure of fertiliser requirements but, unfortunately, that is not yet possible. Analysis of the plant material taken at the correct growth stage offers some promise and the results obtained in this investigation indicate that the determination of the copper content of oat leaves in the early seedling stage may be useful. At

a later stage in the growth reliable differences have not been obtained in Western Australian work. (Teakle, Turton and Throssell, 1940.) Dr. H. C. Forster (private communication) has made available information to the effect that, in Victoria, zinc deficiencies may be detected by analyses made on material collected in the seedling stages but the differences are much more substantial than obtained with copper in this work. As with copper, the differences disappear as the crop matures.

The results of analyses made in the Government Chemical Laboratory are summarised in Table 8.

TABLE 8.

ANALYSES OF PLANT MATERIAL FROM EXPERIMENTS AT GINGIN,
DANDARAGAN, MAIDA VALE AND MERREDIN FOR COPPER CONTENT.

(Analyses made in the Government Chemical Laboratory.)

Treatment.	Copper (Cu) parts per million (ppm) dry matter :			
	Rennie, Moondah.	Roberts, Kayanaba.	Brown, Bidgerabbie.	Barrett- Lennard, Yaodabbie.
(a) Oats—Collected 22nd-23rd July, 1940, 6 weeks after planting—				
No copper (1)	2.3	0.7	1.6	3.7
	(2) 1.6	1.1	1.3	2.9
	(3) ...	2.0	0.9	...
	(4) ...	1.3	1.8	...
Bluestone, 5 lbs. per acre (1)	...	...	2.6	...
	(2) ...	...	3.1	...
	(3) ...	...	4.0	...
	(4) ...	...	3.9	...
Bluestone, 15 lbs. per acre (1)	2.5	2.2	...	4.0
	(2) 2.1	3.0	...	3.3
	(3) ...	3.3	...	...
	(4) ...	3.4	...	...
(b) Oats—Collected 12th September, 1940, 14 weeks after planting—				
No copper (1)	...	...	2.0	...
	(2) ...	...	1.6	...
Bluestone, 5 lbs. per acre (1)	...	...	1.6	...
	(2) ...	...	1.7	...
Treatment	Control, No Copper.	Bluestone, 15 lbs. per acre.	Bluestone, 15 lbs. per acre plus Mn and Zn.	
(c) Oats from Maida Vale—Sampled 12th September, 1939 ; 17 weeks old—				
(1)	47.1*	9.1*	2.4	
(2)	6.6*	2.7	2.1	
(3)	1.9	...	...	
(4)	2.7	...	...	

* Samples evidently contaminated prior to copper estimation.

TABLE 8—*continued*.

Treatment.	Copper (Cu) ppm dry matter. Leaf material sampled.
(d) Subterranean Clover—Sampled 12th September, 1940—	
(1) From control plots—Brown, Bidgerabbie ...	2.6
(2) From copper treated plots—Brown, Bidgerabbie	7.4
(e) Cape weed—Sampled September, 1940—	
(1) Glencoe, Gingin—Sampled 10th September, 1940 :	
No copper fertiliser (1)	6.9
(2)	11.9
Bluestone fertiliser (1)	10.8
(2)	5.8
(2) Roberts, Kayanaba—Sampled 12th Sept., 1940 :	
Controls—Highly deficient patch	8.0
Bluestone, 15 lbs. per acre adjacent ... (1)	6.0
(2)	4.8
(f) Wheat—Merredin Research Station, 1939—Sample taken 28th August, 1939, about 15 weeks after planting :	
Control, no copper	4.1
Bluestone, 15 lbs. per acre	5.4

It is apparent that oats taken at six weeks from planting generally contain less than 2 ppm Cu in the dry matter when obtained from highly deficient areas such as Brown's and Roberts'. Where the deficiency is less acute, as on Rennie's, the figures are slightly higher and on Barrett-Lennard's the figures are still higher. The use of bluestone fertiliser has raised the copper content consistently but the differences are small. Realising this fact, oats, taken in the early seedling stages, may be of some value as an indicator of copper deficient soils.

Subterranean clover appears much more responsive to copper treatment as far as absorption of copper is concerned. Collateral work in another part of the State gives support to these figures and it is expected that analysis of subterranean clover leaves, taken at the correct growth stage, will be a reliable guide to acute copper deficiency in soils.

From these figures cape weed does not appear to have any value as an indicator of copper deficiency in soils.

VI. DISCUSSION AND CONCLUSIONS.

This work gives further substantiation to the results published in earlier numbers of this Journal. Copper deficiency of cereals occurs on a variety of soil types in many parts of the wheat belt and may be corrected by the use of copper containing fertilisers.

It has been established by this work that certain soil types in the Dandaragan district and a variety of the sandy and gravelly wodjil soils of the wheat belt are acutely deficient in copper with respect to the growth of oats, wheat and subterranean clover. Other types are apparently mildly deficient. On these, distinctive copper deficiency symptoms are not obvious, but increased crop growth results from the application of copper.

An interesting symptom observed with some varieties of wheat used in these experiments, for example Bencubbin and Nabawa, on some types of copper deficient soils is a purplish discoloration of the stalks and leaf sheaths. This has already been noted by Stewart and Teakle (1939) and may prove a useful indication of need for copper-containing fertilisers. It has been noted, too, that the copper treated areas on copper deficient land generally carry a more attractive looking crop. It is more golden yellow in colour, the heads look fuller, and the grain more attractive. On the more acutely deficient land no grain may be produced and the empty heads stand erect or, in the case of oats, the husks may be pale and empty. Papery glume of oats occurs but is not very common. Another characteristic of acutely deficient land is the tendency to secondary tillers in late spring. The first tillers may be practically dry at this time, but the plant sends out new green tillers at the base. Of course these do not mature.

Certain of these copper deficient soils give a greater response with impure copper fertilisers, such as roaster residues, than with bluestone. This may indicate the importance of some other element in the nutrition of plants on these soils and requires further investigation. It may be of importance in animal nutrition. Certainly manganese, zinc and boron, etc. failed to improve the yield in a number of cases when used with the bluestone, but it is possible that these were not applied in a manner suitable for beneficial results. On the dark grey calcareous soils near Dongarra the roaster residues gave an improvement estimated to be about 30 per cent. but copper ore was ineffective. In this case, perhaps the zinc content of the residues was important. It is hoped that this may be determined in the coming season.

Perhaps the most interesting discovery in this work is the effect of copper in eliminating dummy heads on certain types of wodjil country. In a number of instances the effect has been spectacular. It is hoped that many farmers will try strips of bluestone and superphosphate across such patches in their paddocks during the coming season in order to explore more generally the situation with respect to copper deficiency. To avoid damage to the seedlings bluestone should be used at not more than 5 lbs. per acre. It seems likely that the one application will be effective over more than one season. Farmers are recommended not to spend money on large quantities of bluestone for fertiliser purposes without first making sure that the treatment will be effective on their particular types of land. To do this all that is necessary is to drill, across the suspected soil types, strips receiving a superphosphate-bluestone mixture supplying bluestone at the rate of about 5 lbs. per acre. These strips should be carefully pegged and compared with adjacent areas receiving the usual superphosphate dressing.

ACKNOWLEDGMENTS.

The thanks of the writers are tendered to those farmers who have made land and plant available and assisted in this work. Grateful acknowledgment is made of the generosity of Messrs. Cuming Smith & Mt. Lyell Farmers Fertilisers Ltd. in donating roaster residues, superphosphate and bluestone and preparing the copper ore for use in the fertiliser mixtures.

Acknowledgment is also made of the assistance of Mr. Harding of the Forests Department in the design of the experiments and the statistical analysis of the results and of the assistance of colleagues in the planting and harvesting of the plots.

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Contagious Abortion-Free Herds.

The following herds have been declared free from contagious abortion in accordance with the requirements of the Scheme for the certifying of herds abortion-free, and unless otherwise declared the certificate remains in force until the date shown in respect of each herd:—

No.	Owner.	No. of Cattle Tested.	Date of Expiry.
1	Agricultural College, Muresk	39	1941.
2	R. J. & A. J. Marshall, Denmark	22	30th September. 31st October.

Government Certified Subterranean Clover Seed.

The following growers of subterranean clover seed have produced Government certified seed during the 1940-41 season:—

E. Farleigh, Boyup Brook—*Midseason* (*Mt. Barker*) and *Early* (*Dwalganup*).

P. D. Forrest, Boyup Brook—*Early* (*Dwalganup*).

L. W. Moore, Benjinup—*Midseason* (*Mt. Barker*) and *Early* (*Dwalganup*).

Summerlea Pastoral Co., Capel—*Midseason* (*Mt. Barker*).

In article (Coast Disease of Sheep in Western Australia, by H. W. Bennetts) March, 1940, Vol. 17, No. 1, p. 48, in lieu of—(c) *Drinking water . . . 400 gallons of drinking water*, substitute:—

Dissolve copper sulphate—5 ozs.

Dissolve cobalt chloride—1 oz.

In water—1 gallon.

Add half-pint of the solution to 400 gallons of drinking water.

Conserve Nitrogenous Fertilisers by Growing Inoculated Legumes.

By W. P. CASS SMITH, Plant Pathologist, Department of Agriculture.

With the advent of the war, attention has been drawn to the shortage of nitrogenous fertilisers manufactured in Australia. It has recently been estimated that whereas some 55,000 tons of sulphate of ammonia were used per annum in pre-war days, only approximately half this amount is likely to be manufactured annually by local industries for some little time to come. In addition, some thousands of tons of nitrate of soda were formerly imported and further supplies may be difficult to obtain.

It is obviously necessary, therefore, to utilise existing supplies of nitrogenous manures to the best possible advantage and to exercise drastic economy where their application is not essential.

INOCULATION EXPERIMENT WITH PEAS CARRIED OUT ON VIRGIN SOIL AT RIDGE HILL, HELENA VALLEY DISTRICT, IN 1938.



Peas in centre row grown from inoculated seed. Peas in alternate rows grown from uninoculated seed.

The increase in the green yield in favour of inoculation amounted to 1,021 per cent.

[Photo Govt. Photographer.]

In the absence of nitrogenous fertilisers the maintenance of combined nitrogen in the soil at a level sufficiently high for profitable crop production may become a very real problem for various producers.

In such cases, if practicable, this difficulty may be largely overcome by the growing of *inoculated* leguminous crops, e.g., peas, beans, lupins, clovers, etc., and by the feeding off in situ or digging, or ploughing under of these crops.

It should be remembered, however, that unless the roots of these leguminous crops are inoculated with appropriate nodule forming bacteria which enable them to draw on the inexhaustible supplies of atmospheric nitrogen, the growing and ploughing under of leguminous crops will not increase the nitrogen content of the soil to any greater extent than would cereals, grasses or other non-legumes.

Past experience in Western Australia has indicated very definitely that much of our agricultural land will not support the growth of the common crop legumes until the requisite root nodule bacteria are introduced for the bacteria specific to native legumes which flourish on this land in its virgin state, appear to be ineffective for the inoculation of agricultural species.

It is largely due to the realisation of this fact by farmers themselves and also because they appreciate the advantages which are obtained from seed inoculation that the bacterial culture service, which was inaugurated by the Department of Agriculture in 1926, has grown to its present dimensions. Since that year some 12,500 pure cultures of nitrogen-fixing bacteria for the inoculation of leguminous seeds have been supplied to farmers, and by this means the nitrogenous fertility of many of our poor soils, and especially those of the subterranean clover belt, has been increased to such an extent that grasses and other non-legumes now grow prolifically without the necessity for applying nitrogenous fertilisers.

On new land, therefore, or on land on which the common crop legumes have not previously been grown, it is a wise precaution to inoculate the seed prior to planting.

CULTURES AVAILABLE.

The bacteria which may be obtained from the Plant Pathology Branch of the Department of Agriculture will inoculate the following groups of legumes. *The members of each group are inoculated by the same kind of bacteria, but the plants mentioned in different groups require different bacteria.* Persons ordering cultures should clearly specify the kind of seed to be inoculated. For example if "pea" bacteria are ordered it is impossible to tell whether "garden" peas, "cow" peas, or Tangier peas, etc., is meant, unless the qualifying word is also indicated.

Group A.—Subterranean clover, drooping-flowered clover, ball or cluster clover, white Dutch clover, perennial red clover ("cow grass"), Egyptian clover (Berseem clover), and all other true clovers (*Trifolium spp.*). (Two strains are kept, one for subterranean clover (Waite Institute strain), and the other (local strain) for other kinds of clovers.)

Group B.—Lucerne, white sweet clover (*melilotus indica*), "King Island Melilot" ("Hexham scent"), medics, trefoils, barrel clover and all other species of *Medicago* or *Melilotus*. (Rothamsted strain.)

Group C.—Garden pea, sweet pea, field pea, all kinds of vetches or tares, broad bean, lentil.

Group D.—Tangier pea (*Lathyrus tangitanus*).

Group E.—Tick bean (*Vicia faba*). Waite Institute strain.

Group F.—W.A. blue lupin (*Lupinus varius*) and N. Zealand blue lupin (*L. angustifolius*).

Group G.—Soy beans (*Glycine Max*).

Group H.—Sulla (*Hedysarum coronarium*).

Group J.—French beans (*Phaseolus vulgaris*), scarlet runner bean (*Phaseolus multiflorus*).

Group K.—Cow peas (*Vigna sinensis*), peanuts (*Arachis hypogoea*), Lima bean (*Phaseolus lunatus*).

Group L.—Japan clover (*Lespedeza spp.*).

Group M.—*Lotus major* and other *Lotus* species.

APPROXIMATE AMOUNT OF SEED WHICH MAY BE TREATED WITH ONE BOTTLE OF CULTURE.

Size of Bottle.	Price. (Post free.)	Seed of size of Lucerne or Sub- Clover, etc.	Seed of size of Garden Pea, Lupin, Soy Beans, etc.	Milk required.	Tri-calcium Phosphate. (Supplied free.)
1 oz.	s. d. 1 6	Up to 15 lbs.	Up to 30 lbs.	½-pint	1.5 gms.
2 oz.	2 6	Up to 30 lbs.	Up to 60 lbs.	½-pint	3.0 gms.
8 oz.	5 0	Up to 120 lbs.	Up to 240 lbs.	1 quart	12.0 gms.

N.B.—If a given size of culture is used to inoculate less seed than stated above the excess will do no harm.

IMPORTANT NOTICE RE ORDERING CULTURES.

Owing to the time taken to prepare the cultures, and owing also to the fact that in the busy time of the year there is frequently a tremendous accumulation of orders, farmers are requested to lodge their applications with the requisite payment enclosed at the Department a fortnight, at least, before they wish the culture to be forwarded.

The following publications may be obtained from the Department of Agriculture, Perth, on application, or will be sent post free to any address in this State on receipt of a remittance for the amount stated:—

The Management of Poultry under Western Australian Conditions, by W. T. Richardson
Poultry Adviser.

This is a most useful and valuable book, not only for beginners, but to all those who keep fowls for pleasure and profit. It deals fully with all matters connected with the industry, including Breeding, Feeding (for stock birds or egg production), Incubating, Brooding and Care of Chicks, Marketing (eggs and poultry), and all matters of use to the poultry-keeper. It also fully describes symptoms of various ailments and diseases and simple treatment for same, and, as the book was written to suit local conditions, every poultry-keeper should have a copy by him. Price, 2s.

The Pruning of Fruit Trees, by J. F. Moody, Fruit Industries Commissioner.

This publication contains numerous illustrations, being reproduction of photographs taken in this State, of pruned and unpruned trees, which make the details set out in the letterpress particularly easy to understand. Price 2s. 6d.

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This publication contains invaluable information on packing and grading fruit for local and export markets. It is freely illustrated, and no fruit-packing shed should be without a copy. Price 1s. 6d.

Butter Fat Tables, by the Department of Agriculture, Dairy Branch.

This publication shows the pounds of Butter Fat in various weights of milk tested by the Babcock Method. It is of value to all who have to assess Butter Fat, and is a handy ready reckoner for this purpose. Price 1s.

The Export Lamb:

This publication contains valuable information on the breeding policy to produce the best type of export lamb desired by the critical London Market. It also gives the results of the early W.A. experiments conducted at the Avondale Research Station, together with information regarding feeding, general treatment, grading, handling and marketing. Price 1s.

Agricultural Problems.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser or Veterinary Officer of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

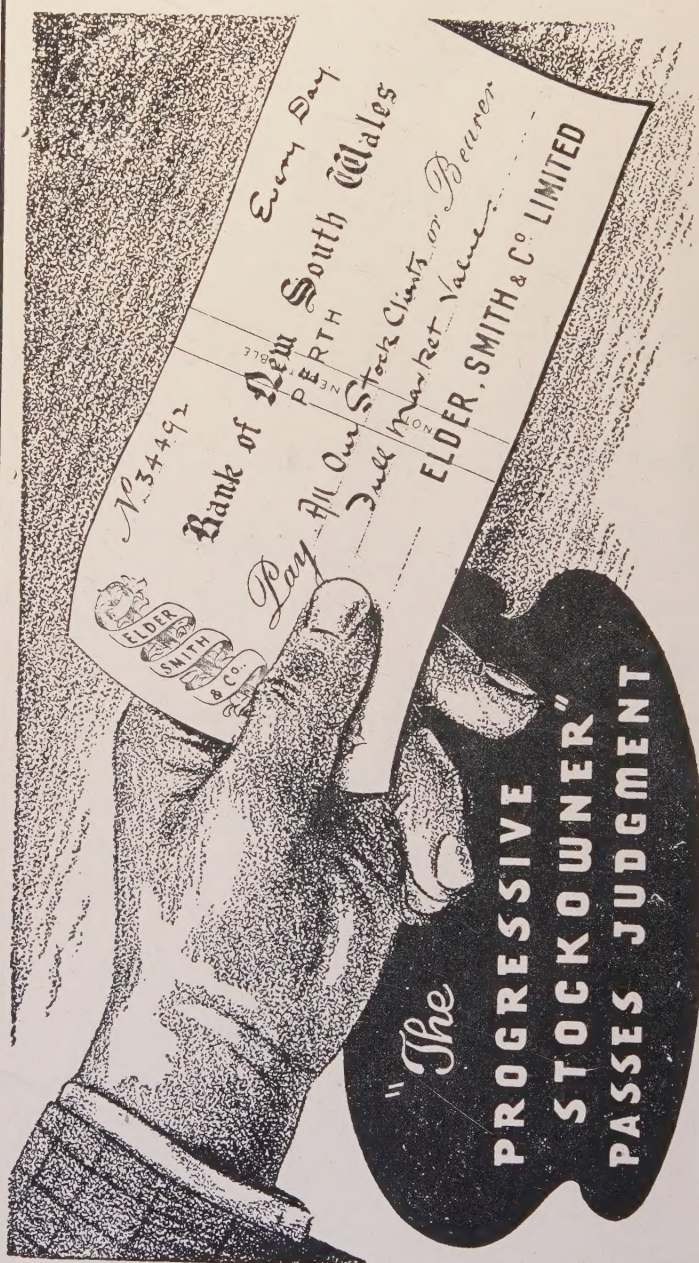
Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—

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